SCIENCE

FRIDAY, DECEMBER 4, 1914

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X-RAYS AND CRYSTALLINE STRUCTURE[1]

Two years have gone by since Dr. Laue made his surprising discovery of the interference effects accompanying the passage of X-rays through crystals. The pioneer experiment has opened the way for many others, and a very large amount of work, theoretical and practical, has now been done. As the preliminary exploration of the new country has proceeded, our first estimate of its resources has grown continuously; we have learned many things which help us to a better understanding of phenomena already familiar, and we have seen avenues of enquiry open out before us which as yet there has been little time to follow. The work is full of opportunities for exact quantitative measurements, where precision is sure to bring its due reward. There is enough work in sight to absorb the energies of many experimenters, and there is sure to be far more than we can see. When we consider the wideness of the new field, the quality and quantity of the work to be done in it, and the importance of the issues, we are scarcely guilty of over-statement if we say that Laue's experiment has led to the development of a new science.

The experiment itself—to put it very briefly—constitutes a proof that X-rays consist of extremely short ether waves. In order to appreciate the value of this demonstration, we must bear in mind the present conditions of our knowledge of the laws of radiation in general. Let us consider very shortly how the whole matter stood when the new work was begun.

When X-rays were first discovered eighteen years ago it was soon pointed out that they might consist of electro-magnetic disturbance of the ether analogous to those supposed to

[1] Read before the weekly evening meeting of the Royal Institution of Great Britain, June 5, 1914.

constitute light. It was true that the new rays seemed to be incapable of reflection, refraction, diffraction and interference, which were familiar optical phenomena. But it was pointed out by Schuster[2] that these defects could be explained as natural consequences of an extremely small wave-length. The positive evidence consisted mainly in the knowledge that the impact of the electrons on the anti-cathode of the X-ray bulb ought to be the occasion of electro-magnetic waves of some sort, and in the discovery by Barkla that the X-rays could be polarized, which last is a property also of light.

As experimental evidence accumulated, a number of results were found which the electromagnetic theory was unable to explain, at least in a direct and simple manner. They were mainly concerned with the transference of energy from place to place. In some way or other the swiftly moving electron of the X-ray bulb transfers its energy to the X-ray, and the X-ray in its turn communicates approximately the same quantity of energy to the electron which originates from matter lying in the track of the X-ray, and which is apparently the direct cause of all X-ray effects. Experiment seemed to indicate that X-ray energy traveled as a stream of separate entities or quanta, the energy of the quantum differing according to the quality of the X-ray. It looked at one time as if it might be the simplest plan to deny the identity in nature of X-rays and light, to describe the former as a corpuscular radiation and the latter as a wave motion. Otherwise, it seemed that the electromagnetic hypothesis would be torn to pieces in the effort to hold all the facts together.

But it appeared on a close examination of light phenomena also, though in much less obvious fashion, that the very same effects occurred which in the case of X-rays were so difficult to explain from an orthodox point of view. In the end it became less difficult to deny the completeness of the orthodox theory than the identity in nature of light and X-rays. Modern work on the distribution of energy in the spectrum, and the dependence of specific heat upon temperature, has also led independently to the same point of view. It has been urged with great force by Planck, Einstein and others that radiated energy is actually transferred in definite units or quanta, and not continuously; as if we had to conceive of atoms of energy as well as of atoms of matter. Let it be admitted at once that the quantum theory and the orthodox theory appear to stand in irreconcilable opposition. Each by itself correlates great series of facts; but they do not correlate the same series. In some way or other the greater theory must be found, of which each is a partial expression.

The new discovery does not solve our difficulty at once, but it does two very important things. In the first place, it shows that the X-rays and light are identical in nature; in fact, it removes every difference except in respect to wave-length. The question as to the exact place where the difficulty lies is decided for us; we are set the task of discovering how a continuous wave motion, in a continuous medium, can be reconciled with discontinuous transferences of radiation energy. Some solution there must be to this problem. The second important thing is that the new methods will surely help us on the way to find that solution. We can now examine the X-rays as critically as we have been able to study light, by means of the spectrometer. The wave-length of the X-ray has emerged as a measurable quantity. The complete range of electromagnetic radiations now lies before us. At one end are the long waves of wireless telegraphy, in the middle are first the waves of the infra-red detected by their heating effects, then the light waves, and then the short waves of the ultra-violet. At the other end are the extremely short waves that belong to X-radiation. In the comparative study of the properties of radiation over this very wide range we must surely find the answer to the greatest question of modern physics.

So much for the general question. Let us now consider the procedure of the new investigations, and afterwards one or two applications to special lines of enquiry.

The experiment due to Laue and his collab-

[2] *Nature*, January 23, 1896.

orators Friedrich and Knipping has already been described in this lecture room and is now well-known. A fine pencil of X-rays passes through a thin crystal slip and impresses itself on a photographic plate. Round the central spot are found a large number of other spots, arranged in a symmetrical fashion, their arrangement clearly depending on the crystal structure. Laue had anticipated some such effect as the result of diffraction by the atoms of the crystal. His mathematical analysis is too complicated to be described now, and indeed it is not in any circumstances easy to handle. It will be better to pass on at once to a very simple method of apprehending the effect which was put forward soon after the publication of Laue's first results. I must run the risk of seeming to be partial if I point out the importance of this advance, which was made by my son W. Lawrence Bragg. All the recent investigations of X-ray spectra and the examination of crystal structure and of molecular motions which have been carried out since then have been rendered possible by the easy grasp of the subject which resulted from the simpler conception.

Let us imagine that a succession of waves constituting X-radiation falls upon a plane containing atoms, and that each atom is the cause of a secondary wavelet. In a well known manner, the secondary wavelets link themselves together and form a reflected wave. Just so a sound wave may be reflected by a row of palings, and very short sound waves by the fibers of a sheet of muslin.

Suppose a second plane of atoms to lie behind the first and to be parallel to it. The primary wave weakened somewhat by passing through the first plane, is again partially reflected by the second. When the two reflected pencils join it will be of great importance whether they fit crest to crest and hollow to hollow, or whether they tend to destroy each other's effect. If more reflecting planes are supposed, the importance of a good fit becomes greater and greater. If the number is very large, then, as happens in many parallel cases in optics, the reflected waves practically annul each other unless the fit is perfect.

It is easily seen that the question of fit depends on how much distance a wave reflected at one plane loses in comparison with the wave which was reflected at the preceding plane: the fit will be perfect if the loss amounts to one, two, three, or more wave-lengths exactly. In its turn the distance lost depends on the spacing of the planes, that is to say, the distance from plane to plane, on the wave-length and on the angle at which the rays meet the set of planes.

The question is formally not a new one. Many years ago Lord Rayleigh discussed it in this room, illustrating his point by aid of a set of muslin sheets stretched on parallel frames. The short sound waves of a high pitched bird call were reflected from the set of frames and affected a sensitive flame; and he showed how the spacing of the planes must be carefully adjusted to the proper value in relation to the length of wave and the angle of incidence. Rayleigh used the illustration to explain the beautiful colors of chlorate of potash crystals. He ascribed them to the reflection of light by a series of parallel and regularly spaced twinning planes within the crystal, the distance between successive planes bearing roughly the same proportion to the length of the reflected wave of light as the distance between the muslin sheets to the length of the wave of sound.

Our present phenomenon is exactly the same thing on a minute scale: thousands of times smaller than in the case of light, and many millions of times smaller than in the case of sound.

By the kindness of Professor R. W. Wood I am able to show you some fine examples of the chlorate of potash crystals. If white light is allowed to fall upon one of them, the whole of it is not reflected. Only that part is reflected which has a definite wave-length or something very near to it, and the reflected ray is therefore highly colored. The wave-length is defined by the relation already referred to. If the angle of incidence is altered, the wave-length which can be reflected is altered, and so the color changes.

It is not difficult to see the analogy between

these cases and the reflection of X-rays by a crystal. Suppose for example that a pencil of homogeneous X-rays meets the cube face of such a crystal as rocksalt. The atoms of the crystal can be taken to be arranged in planes parallel to that face, and regularly spaced. If the rays meet the face at the proper angle, and only at the proper angle, there is a reflected pencil. It is to be remembered that the reflection is caused by the joint action of a series of planes, which, in this case, are parallel to the face; it is not a reflection by the face itself. The face need not even be cut truly: it may be unpolished or deliberately roughened. The reflection takes place in the body of the crystal, and the condition of the surface is of little account.

The allotment of the atoms to a series of planes parallel to the surface is not of course the only one possible. For example in the case of a cubic crystal, parallel planes containing all the atoms of the crystal may also be drawn perpendicular to a face diagonal of the cube, or to a cube diagonal, or in many other ways. We may cut the crystal so as to show a face parallel to any series, and then place the crystal so that reflection occurs, but the angle of incidence will be different in each case since the spacings are different. It is not necessary to cut the crystal except for convenience. If wave-length, spacing and angle between ray and plane are rightly adjusted to each other, reflection will take place in the crystal independently of any surface arrangement.

This is the "reflection" method of explaining the Laue photograph. W. L. Bragg showed in the first place that it was legitimate, and in the second that it was able to explain in the position of all the spots which Laue found upon his photographs. The different spots are reflections in different series of planes which may be drawn to contain the atoms of the crystal. The simpler conception led at once to a simpler procedure. It led to the construction of the X-ray spectrometer, which resembles an ordinary spectrometer in general form, except that the grating or prism is replaced by a crystal and the telescope by an ionization chamber and an electroscope. In use a fine pencil of X-rays is directed upon the crystal, which is steadily turned until a reflection leaps out; and the angle of reflection is then measured. If we use different crystals or different faces of the same crystal, but keep the rays the same, we can compare the geometrical spacings of the various sets of planes. If we use the same crystal always, but vary the source of X-rays, we can analyze the latter, measuring the relative wave-lengths of the various constituents of the radiation.

We have thus acquired a double power: (1) We can compare the intervals of spacing of the atoms of a crystal or of different crystals, along various directions within the crystal; in this way we can arrive at the structure of the crystal. (2) We can analyze the radiation of an X-ray bulb; in fact we are in the same position as we should have been in respect to light if our only means of analyzing light had been by the use of colored glasses, and we had then been presented with a spectrometer, or some other means of measuring wave-length exactly.

We now come to a critical point. If we knew the exact spacings of the planes of some one crystal, we could now by comparison find the spacings of all other crystals, and measure the wave-length of all X-radiations; or if we knew the exact value of some one wave-length, we could find by comparison the values of all other wave-lengths, and determine the spacings of all crystals. But as yet we have no absolute value either of wave-length or of spacings.

The difficulty appears to have been overcome by W. L. Bragg's comparison of the reflecting effect in the case of rocksalt or sodium chloride, and sylvine or potassium chloride. These two crystals are known to be "isomorphous"; they must possess similar arrangements of atoms. Yet they display a striking difference both in the Laue photograph and on the spectrometer. The reflections from the various series of planes of the latter crystal show spacings consonant with an arrangement in the simplest cubical array, of which the smallest element is a cube at each corner of which is placed the same group, a single

atom or molecule, or group of atoms or molecules. In the case of rocksalt, the indications are that the crystal possesses a structure intermediate between the very simple arrangement just described and one in which the smallest element is a cube having a similar group of atoms or molecules at every corner and at the middle point of each face. The arrangement is called by crystallographers the face centered cube. The substitution of the sodium for the potassium atom must transform one arrangement into the other. This can be done in the following way, if we accept various indications that atoms of equal weight are to be treated as equivalent. Imagine an elementary cube of the crystal pattern to have an atom of chlorine at every corner and in the middle of each face, and an atom of sodium or potassium as the case may be, at the middle point of each edge and at the center of the cube. We have now an arrangement which fits the facts exactly. The weights of the potassium and chlorine atoms are so nearly the same as to be practically equivalent, and when they are considered to be so, the arrangement becomes the simple cube of sylvine. But when the lighter sodium replaces the potassium as in rocksalt the arrangement is on its way to be that of the face centered cube, and would actually become so were the weight of the sodium atoms negligible in comparison with those of chlorine. Of course the same result would follow were two or three, or any number of atoms of each sort to take the place of the single atom, provided the same increase were made in the number of the atoms of both sorts. We might even imagine two sorts of groups of chlorine and metal atoms, one containing a preponderance of the former, the other of the latter, but so that two groups, one of each kind, contain between them the same proportion of chlorine and metal as the crystal does. We must merely have two groups which differ in weight in the case of rocksalt, and are approximately equal in weight in the case of sylvine. But it was best to take the simplest supposition at the outset; and now the evidence that the right arrangement has been chosen is growing as fresh crystals are measured. For it turns out that in all crystals so far investigated, the number of atoms at each point must always be the same. Why, then, should it be more than one? Or in other words, if atoms are always found in groups of a certain number, ought not that group to be called the atom?

As soon as the structure of a crystal has been found we can at once find by simple arithmetic the scale on which it is built. For we know from other sources the weight of individual atoms, and we know the total weight of the atoms in a cubic centimeter of the crystal. In this way we find that the nearest distance between two atoms in rocksalt is 2.81×10^{-8} cm., which distance is also the spacing of the planes parallel to a cube face. From a knowledge of this quantity the length of any X-ray wave can be calculated at once as soon as the angle of its reflection by the cube face has been measured. In other words, the spectrometer has now become a means of measuring the length of waves of any X-radiation, and the actual spacings of the atoms of any crystal.

From this point the work branches out in several directions. It will not be possible to give more than one or two illustrations of the progress along each branch.

Let us first take up the most interesting and important question of the "characteristic" X-rays. It is known that every substance when bombarded by electrons of sufficiently high velocity emits X-rays of a quality characteristic of the substance. The interest of this comparison lies in the fact that it displays the most fundamental properties of the atom. The rays which each atom emits are characteristic of its very innermost structure. The physical conditions of the atoms of a substance and their chemical associations are largely matters of the exterior: but the X-rays come from the interior of the atoms and give us information of an intimate kind. What we find is marked by all the simplicity we should expect to be associated with something so fundamental.

All the substances of atomic weight between about 30 and 120 give two strongly defined "lines"; that is to say, there are found among

the general heterogeneous radiation two intense almost homogeneous sets of waves. For instance, rhodium gives two pencils of wave-lengths, approximately equal to 0.61×10^{-8} cm. and 0.54×10^{-8} cm. respectively. More exactly the former of these is a close doublet having wave-lengths 0.619×10^{-8} and 0.614×10^{-8}. The wave-lengths of palladium are nearly 0.58×10^{-8} and 0.51×10^{-8}; nickel 1.66×10^{-8} and 1.50×10^{-8}. Lately Moseley has made a comparative study of the spectra of the great majority of the known elements, and has shown that the two-line spectrum is characteristic of all the substances whose atomic weights range from that of aluminium, 27, to that of silver, 108. These X-rays constitute, there is no doubt whatever, the characteristic rays which Barkla long ago showed to be emitted by this series of substances.

Now comes a very interesting point. When Moseley sets the increasing atomic weights against the corresponding decreasing wave-lengths, the changes do not run exactly parallel with each other. But if the wave-lengths are compared with a series of natural numbers everything runs smoothly. In fact it is obvious that the steady decrease in the wave-length as we pass from atom to atom of the series in the periodic table implies that some fundamental element of atomic structure is altering by equal steps. There is excellent reason to believe that the change consists in successive additions of the unit electric charge to the nucleus of the atom. We are led to think of the magnitude of the nucleus of any element as being simply proportional to the number indicating the place of the element in the periodic table, hydrogen having a nuclear change of one unit, helium two, and so on. The atomic weights of the successive elements do not increase in an orderly way; they mount by steps of about two, but not very regularly, and sometimes they seem absolutely to get into the wrong order. For example, nickel has an atomic weight of 58.7, whereas certain chemical properties and still more its behavior in experiments on radio-activity indicate that it should lie between cobalt (59) and copper (63.6). But the wave-lengths, which are now our means of comparison, diminish with absolute steadiness in the order cobalt, nickel, copper. Plainly, the atomic number is a more fundamental index of quality than the atomic weight.

It is very interesting to find, in the series arranged in this way, four, and only four, gaps which remain to be filled by elements yet undiscovered.

Let us now glance at another and most important side of the recent work, the determination of crystalline structure. We have already referred to the case of the rocksalt series, but we may look at it a little more closely in order to show the procedure of crystal analysis.

The reflection of a pencil of homogeneous rays by a set of crystalline planes occurs, as already said, at a series of angles regularly increasing; giving as we say, spectra of the first, second, third orders, and so on. When the planes are all exactly alike and equally spaced the intensities of the spectra decrease rapidly as we proceed to higher orders, according to a law not yet fully explained. This is, for example, the case with the three most important sets of planes of sylvine, those perpendicular to the cube edge, the face diagonal, and the cube diagonal respectively. An examination of the arrangement of the atoms in the simple cubical array of sylvine shows that for all these sets the planes are evenly spaced and similar to each other. It is to be remembered that the potassium atom and the chlorine atom are so nearly equal in weight that they may be considered effectively equal. In the case of rocksalt the same may be said of the first two sets of planes, but not of the third. The planes perpendicular to the cube diagonal are all equally spaced, but they are not all of equal effect. They contain alternately, chlorine atoms (atomic weight 35.5) only and sodium atoms (atomic weight 23) only. The effect of this irregularity on the intensities of the spectra of different orders is to enhance the second, fourth, and so on in comparison with the first, third and fifth. The analogous effect in the case of light is given by a grating in which the lines are alternately light and

heavy. A grating specially ruled for us at the National Physical Laboratory shows this effect very well. This difference between rocksalt and sylvine and its explanation in this way constituted an important link in W. Lawrence Bragg's argument as to their structure.

When, therefore, we are observing the reflections in the different faces of a crystal in order to obtain data for the determination of its structure, we have more than the values of the angles of reflection to help us; we have also variations of the relative intensities of the spectra. In the case just described we have an example of the effect produced by want of similarity between the planes, which are, however, uniformly spaced.

In the diamond, on the other hand, we have an example of an effect due to a peculiar arrangement of planes which are otherwise similar. The diamond crystallizes in the form of a tetrahedron. When any of the four faces of such a figure is used to reflect X-rays, it is found that the second order spectrum is missing. The analogous optical effect can be obtained by ruling a grating so that, as compared with a regular grating of the usual kind, the first and second, fifth and sixth, ninth and tenth alone are drawn. To put it another way, two are drawn, two left out, two drawn, two left out, and so on. The National Physical Laboratory has ruled a special grating of this kind also for us, and the effect is obvious. The corresponding inference in the case of the diamond is that the planes parallel to any tetrahedral face are spaced in the same way as the lines of the grating. Every plane is three times as far from its neighbor on one side as from its neighbor on the other. There is only one way to arrange the carbon atoms of the crystal so that this may be true. Every atom is at the center of a regular tetrahedron composed of its four nearest neighbors, an arrangement best realized by the aid of a model. It is a beautifully simple and uniform arrangement, and it is no matter of surprise that the symmetry of the diamond is of so high an order. Perhaps we may see also, in the perfect symmetry and consequent effectiveness of the forces which bind each atom to its place, an explanation of the hardness of the crystal.

Here, then, we have an example of the way in which peculiarities of spacing can be detected. There are other crystals in which want of uniformity both in the spacings and in the effective value of the planes combine to give cases still more complicated. Of these are iron pyrites, calcite, quartz and many others. It would take too long to explain in detail the method by which the structures of a large number of crystals have already been determined. Yet the work done already is only a fragment of the whole, and it will take no doubt many years, even though our methods improve as we go on, before the structures of the most complicated crystals are satisfactorily determined.

On this side then we see the beginning of a new crystallography which, though it draws freely on the knowledge of the old, yet builds on a firmer foundation since it concerns itself with the actual arrangement of the atoms rather than the outward form of the crystal itself. We can compare with the internal arrangements we have now discovered the external forms which crystals assume in growth, and the modes in which they tend to come apart under the action of solvents and other agents. By showing how atoms arrange and disarrange themselves under innumerable variations of circumstances we must gain knowledge of the nature and play of the forces that bind the atoms together.

There is yet a third direction in which enquiry may be made, though as yet we are only at the beginning of it. In the section just considered we have thought of the atoms as at rest. But they are actually in motion, and the position of an atom to which we have referred so frequently must be an average position about which it is in constant movement. Since the atoms are never exactly in their places, the precision of the joint action on which the reflection effect depends suffers materially. The effect is greater the higher the order of the spectrum. When the crystal under examination is contained within a suitable electric furnace and the atoms vibrate more violently

through the rise of temperature, the intensities of all orders diminish, but those of higher order much more than those of lower. The effect was foreseen by the Dutch physicist Debije, and the amount of it was actually calculated by him on certain assumptions. I have found experimental results in general accord with his formula. In passing it may be mentioned that as the crystal expands with rise of temperature the spacing between the planes increases and the angles of reflection diminish, an effect readily observed in practise.

This part of the work gives information respecting the movements of the atoms from their places, the preceding respecting their average positions. It is sure, like the other, to be of much assistance in the enquiry as to atomic and molecular forces, and as to the degree to which thermal energy is locked up in the atomic motions.

This brief sketch of the progress of the new science in certain directions is all that is possible in the short time of a single lecture: but it may serve to give some idea of its fascination and possibilities.

William H. Bragg

Walter Holbrook Gaskell (1847–1914)

Dr. Walter Holbrook Gaskell, university lecturer on physiology and prælector on natural science at the University of Cambridge since 1883, died suddenly, after a short illness, on September 7, 1914. He came of a well-known Unitarian family in the north of England, and was born at Naples, on November 1, 1847. After receiving his preliminary education, he entered Trinity College, Cambridge, in 1865, subsequently taking a medical degree at University College, London, in 1878. At Cambridge, Gaskell was one of the earliest to come under the influence of Michael Foster, then prælector on physiology, and, at his instance, entered Ludwig's laboratory at Leipzig in 1874. Prior to Foster's advent, Gaskell had specialized in mathematics, being one of the wranglers in the Mathematical Tripos in 1869. From the date of his first paper, an important research on the vaso-dilator fibers of striated muscle,[1] the rest of his life was devoted to those researches on the motor mechanism of the heart and the sympathetic system which have made his name so well known in physiology and clinical medicine.

English physiology in the first half of the nineteenth century was represented mainly by the work of Sir Charles Bell (spinal nerve roots), Marshall Hall (reflex action), William Sharpey (ciliary motion), Sir William Bowman (theory of urinary secretion), William Prout (HCl in the gastric juice) and Thomas Graham (osmosis, colloids). In 1867 Michael Foster was Sharpey's assistant at University College, and, in 1870, at Huxley's instance, became prælector at Cambridge, while Burdon Sanderson became Waynefleet professor of physiology at Oxford in 1882. From the teaching and inspiration of these two men came most of the brilliant names which have distinguished English physiology in the later period, with the exception of Starling, whose name is associated with Guy's Hospital. Schaefer was a Sharpey pupil, and was persuaded by Foster to devote his life to research. Leonard Hill and Gotch were Oxford men. From Cambridge came Langley, Henry Head, Sherrington, Roy, Adami, Gowland Hopkins and Gaskell.

When Gaskell began to work with Ludwig, every one believed in the so-called neurogenic theory of the heart's action, introduced by Borelli in 1680, viz., that the heart's movements, beat and tonus are due to nervous impulses. A little before Borelli, Harvey, in his demonstration of the circulation of the blood (1628), had advanced the idea that the heart is a muscular force pump, propelled by its own internal heat. This mystic dogma (the myogenic theory) was stated in more modern form by Haller in 1757, viz., that the heart's contraction is due to an inherent "irritability" of its muscle, the stimulus being the entrance and passage of venous blood through it. Both theories, neurogenic and myogenic, have had their ups and their downs to date. The neurogenic theory was restated by Legallois in

[1] *Proc. Roy. Soc. Lond.*, 1877, XXV., 439–445.

1812, and seemingly confirmed by the Webers' discovery that stimulation of the vagus nerve will stop the heart (1845); and by the discovery of intrinsic nerve ganglia in the heart by Remak (1848) and Bidder (1852), which were thought to be involved in the celebrated experiment of Stannius (1852), viz., that a ligature or cut between the sinus venosus and the auricles produces standstill, while a second ligature applied to the auriculo-ventricular groove causes the ventricle to beat again. The modern revival of the myogenic theory is the work of Engelmann and Gaskell.

Between 1874 and 1881, Gaskell made a long series of ingenious investigations upon the musculature and innervation of the heart, the results of which, as given in his great memoir of 1881[2] and later, may be summarized, however inadequately, as follows:

1. The motor impulses from the nerve ganglia in the sinus venosus are discrete, not continuous, stimuli, influencing the rhythm of the heart (its rate and force) but not originating either its movements or its beat.

2. Cardiac muscle can contract of itself and is a stimulus-producer. The five properties of cardiac (or other) muscle, as deduced by Gaskell, are excitability, conductivity, tonicity, rhythmicity and automatic contractile power. This power of automatic, rhythmic contractility has been recently confirmed in Burrows's extra-vital cultures of embryonic heart muscle,[3] which contain no nervous tissue whatever.

3. That the automatic contraction wave proceeds from sinus venosus to ventricle without nervous intervention is proved by Gaskell's and Engelmann's sections in the cardiac muscle, excluding the nervous tissues, and leaving only a narrow isthmus for the transmission of the rhythmic impulse. Gaskell reversed this peristaltic wave by stimulating the ventricle after the second Stannius ligature, showing that the normal impulse could not have started from the cardiac ganglia.

4. Gaskell first produced experimental "heart-block" (a term of his invention) by clamping the auriculo-ventricular and sino-auricular grooves, which he calls "the two natural blocking points" of the muscular contraction wave. In his view, the original Stannius experiments become simple cases of temporary block. This view has been brilliantly confirmed by the discovery of the vestigial muscular structures known as the auriculo-ventricular bundle of His and the sino-auricular node of Keith and Flack; also by the clinical and pathological findings in the disease described by Morgagni in 1761 and now known as heart-block or the Stokes-Adams syndrome. Gaskell even produced the two-, three- and four-time gallops of modern clinicians, in which the ventricle drops one or more of its beats. Schiff's observation that the ventricle of a dying heart beats slower than the auricle is interpreted as the effect of a gradually increasing block. Gaskell also produced the clinical condition known as "fibrillation of the heart" in an isolated strip of cardiac muscle, interpreting the phenomenon as due to blocking of the connections between individual muscle cells. In recent medicine, the various rhythmic disorders of the heart are regarded, not as cases of nervous imbalance, but as the effects of blocking of the peristaltic wave which passes from sinus venosus to bulbus arteriosus, and from muscle fiber to muscle fiber.

5. Schmiedeberg's observation that stimulation of the vagus after administration of nicotine will accelerate the heart led Gaskell to a series of investigations in comparative histology. He found that the hearts of warm-blooded and cold-blooded animals have the same innervation, that the inhibitory fibers of the vagus are medullated, the accelerator fibers non-medullated, leading to the important conclusion that both sets of fibers belong, not to the cerebro-spinal system, but to "the great system of efferent ganglionated nerves" (autonomic system), the function of which is the redistribution of impulses along collateral paths by means of fibers passing to and from an especial sympathetic ganglion or synapse. The efferent nerve cells of the inhibitory system lie in the heart itself, those of the accelerator system lie in external sympathetic ganglia, the nerve cells in either case being a switch (Foster's synapse) for the transmission of impulses. In 1890, Langley showed that nicotine will paralyze the medullated or pre-ganglionic fiber of a sympathetic ganglion without affecting the non-medullated (post-ganglionic) fiber. Schmiedeberg's experiment was, therefore, only a special case of Langley's nicotine effect. He was really stimulating the preganglionic or inhibitory fibers of the vagus; the switchboard effect across the synapse was abolished, the accelerator fibers from the external ganglia being unaffected by the poison.

[2] *Phil. Tr.*, Lond., 1883, CLXXIII., 993–1033.

[3] SCIENCE, 1912, XXXVI., 90–92.

6. The vagus, therefore, acts both as whip and bridle, spur and snaffle to the heart. The intrinsic ganglia being only bridges for the transmission of impulse, the true function of the vagus, in Gaskell's view, is not inhibitory but *quiescent*, acting upon the heart muscle itself. Gaskell revives Borelli's hypothesis[4] that the effect is chemical. The vagus is defined as the anabolic nerve of the heart. Inhibition is anabolism.[5] The vagus is a trophic nerve, both for muscle and ganglia.

7. Galvanometer observations showed that stimulation of the accelerator and inhibitor fibers produced opposite electrical effects which were independent of contraction, since they could be observed in a quiescent heart. These electromotive effects were first mapped and measured by A. D. Waller in 1889. Einthoven's string galvanometer made it possible for the physician to obtain "electrocardiograms" or telegrams from the heart, giving its electromotive condition, a field of investigation which Gaskell was the first to enter.

8. Gaskell regards certain discrepancies in the findings of experimentation upon the heart as due to chemical and nutritive changes in different hearts at different times of the year.

These results, the most important work on the heart since Ludwig, are embodied partly in Gaskell's Croonian Lecture of 1881, and, in more mature and complete form, in his splendid monograph in Schaefer's "Physiology" (1898). His comparative researches on the innervation of different animals lead him to his next great work, the mapping out and interpretation of the nerve supply of the entire vascular and visceral systems, culminating in his exhaustive memoir of 1886.[6] In this, it was shown, by microscopical observation, that the supply of nerves from the spinal cord to the chain of sympathetic ganglia originates mainly from the thoracic and upper lumbar regions, in which white rami, made up of medullated nerves, form the connection. Although it is now known that the cerebro-spinal system alone governs reflex actions, it was formerly supposed that the sympathetic system was also concerned in the change of afferent impulses to efferent. The mapping out of the sympathetic nerves in their distribution from the spinal roots between the second thoracic and second lumbar vertebræ and the inclusion of the nerves proceeding from the cranial and sacral nerve roots, as a part of a greater system, distributed to the viscera, blood vessels, ductless glands and all organs or regions supplied by smooth (involuntary) muscle, was the special work done by Gaskell. This system was defined and interpreted by Langley as the "autonomic" system, the function of the sympathetic and cranio-sacral autonomics being the redistribution of impulses along all efferent paths which do not terminate in voluntary muscle, these paths proceeding from a neuron in the spinal cord to an external sympathetic ganglion or synapse, from whence the post-ganglionic fibers pass to the glands or muscles. The study of these paths began with Gaskell's investigations on the accelerator nerves of the heart. Langley's nicotine method proved the means of isolating individual synapses, as the drug acts selectively on the autonomic ganglia and not on the cerebro-spinal. In internal medicine, the connection of the autonomic systems with the ductless glands forms part of the interesting theory of the correlation of the internal secretions advanced by the Viennese clinicians, Eppinger, Falta and Rüdinger.

The remaining years of Gaskell's life were taken up with his theory, formulated in 1889, that the central canal of the nervous system was originally the lumen of a primitive gut, which is elucidated at length in his book on "The Origin of Vertebrates" (1908). In 1893, in connection with his work on the Hyderabad Chloroform Commission, Gaskell,

[4] Borelli believed that a contracting muscle actually increases in bulk through a fermentation started in its substance from a hypothetic "*succus*" discharged from the nerve.

[5] This view is opposed by Langley, and it does not harmonize with the experiments on isolated hearts in Ringer's solution by Howell and others. The limiting semi-permeable envelope of a living cell, organ or body is usually regarded as the agent of anabolism, preventing the undue dissipation of energy.

[6] "On the Structure, Distribution and Function of the Nerves which Innervate the Visceral and Vascular Systems," *Jour. Physiol.*, Lond., 1886, VII., 1–80.

with Dr. L. E. Shore, made an interesting contribution to pharmacology,[7] showing that chloroform lowers blood pressure by acting directly upon the heart, and not on the vasomotor center, as had hitherto been supposed.

Gaskell was an unassuming, sympathetic character, and it is said that every physiologist who has worked in the Cambridge Laboratory since its start was his personal friend. His eminent colleague, Professor J. N. Langley, thus describes him:

> Gaskell cared little for public ceremonies, and rarely attended the congresses which beset the path of prominent scientific men. He loved to work quietly, to cultivate his garden, to see his friends, and to take a hand at whist or bridge. His house at Great Shelford was a recognized meeting-place for physiologists, and his frank and genial welcome will be an abiding recollection to all who knew him.

F. H. GARRISON

ARMY MEDICAL MUSEUM

DR. GASKELL'S WORK ON ORGANIC EVOLUTION

IT is not with any idea of writing an appreciation either of the man or of his work as a whole that I venture to present this sketch. His work within the limits of the narrower field of physiology—the observations on the effect of a rise in tension of the muscles upon the caliber of the lymphatic vessels, the long series of experiments upon the relation of the vagus and accelerator nerves to the heart and on cardiac muscle, the work on the nerves to the salivary gland—has been dwelt upon by others.[1] I wish rather to call attention to some of the unusual features, and their bearing on the wider biological problems of the day.

Gaskell's work on the origin of vertebrates was begun under conditions that most investigators would consider unfavorable. His wife became afflicted with an obscure nervous disorder, not diagnosed at that rather early date, and his presence was required more and more at his home. Not wishing to give up investigation during his enforced absence from the laboratory, and having his attention turned toward the central nervous system, he began to enquire into its origin and development in the various animal phyla. Regarding the nervous system as the fixed and permanent structure in phylogenetic development, he concluded that the alimentary tract might be the thing to be made over in the transition from the invertebrate with ventral nerve cord to vertebrate with its dorsal nerve cord, and drew up his scheme of the origin of the vertebrates on this basis. Although Gaskell has brought together a vast amount of evidence bearing on this point,[2] his theory has been treated with scant courtesy by most morphologists. It is a common occurrence to hear it glibly and vigorously condemned by people who have never read his book or weighed independently for themselves the evidence adduced in support of the theory. It is worthy of remark in this connection that Gaskell was a pioneer worker in a line which has led in very recent years to the development of a large and important field in the morphology of the central nervous system—the field now included in the component theory of nerves. And he has shown in a way which has had its influence upon other theories of the origin of vertebrates, that the older idea of the formation of a new nervous system while the alimentary tract remained intact in phylogeny is not an assumption to be made lightly. But whether the theory of the origin of vertebrates as he propounded it be right or wrong, a matter which I venture to regard as still unsettled, certain of Gaskell's conceptions of the nature of fundamental biological processes are firmly and surely grounded. It is of these that I wish more particularly to speak.

Gaskell recognized very clearly the importance of the rôle played by internal processes in evolution. In 1910, he wrote:

> Now the formation of the Metazoa from the Protozoa and the progress of the Metazoa upwards signifies that the separate units composing

[7] Lancet, Lond., 1893, I., 386.

[1] Langley, *Nature*, 1914, Vol. 94, No. 2343, p. 93. *British Medical Journal*, 1914, No. 2804, p. 559.

[2] Gaskell, "The Origin of Vertebrates," New York and London, 1908.

the individual have been coordinated for the well-being of that individual. Such coordination has taken place in two ways: (1) a chemical method, by the formation of hormones; (2) a nervous method, by the formation of a central nervous system, and it is self-evident that as soon as a central nervous system is formed, such nervous coordination, especially in connection with the formation of the special senses of sight and smell, must become the important factor in the life of the individual, and its further and further development must constitute the most important factor for the upward progress of the animal race.[3]

The fundamental importance of this idea is likely to be lost for the general reader in the almost platitudinous simplicity of the statement. In reality, there is much matter for long and profound reflection. The idea of chemical coordination, although of comparatively recent development, has claimed the attention of a host of workers, partly perhaps because of its novelty, and the nervous mechanism has, by contrast, become a neglected field. But in the development of the purely chemical mechanisms of coordination, so far as they have been traced at present, we find that they reach their maximum efficiency and complexity well down in the mammalian phylum. It is probable that, so far as the purely chemical mechanisms are concerned, man is not a more complex animal than the rabbit, and certainly not a more complex animal than the dog. Yet the total difference between man and the rabbit or the dog is considerable. The reason for this difference is not far to seek. It lies in the difference of the nervous systems of the two forms, and in the interaction of this system with the chemical mechanisms of coordination. After the chemical mechanisms have reached their zenith, the nervous system still shows, step by step, an increasing complexity, functionally as well as structurally, as successively higher types of animals are examined.

I walked out to Dr. Gaskell's house from Cambridge early one August afternoon two years ago, intending to make a brief call, but the afternoon was far gone and the sun low in the west before I started for the little railroad station at Great Shelford. The conversation turned on the rôle of the internal factors in evolution. He remarked:

> It is not size, it is not strength, that has conferred the great advantage in the struggle, but acuteness.

The hand and arm of man are often cited as adaptations of a high degree of perfection conferring a great advantage upon its possessor. This is but a part of the story. The hand and arm without a nervous system to control or coordinate its movements would be valueless. The hand and arm of a recent hemiplegic may have lost little or nothing in bone or muscle, but, despite its complex structure, it is of less use to its possessor than the foreleg and hoof of a horse. The clot of blood in the cerebrum has wrecked the mechanism which also is necessary if the marvelous hand of man is to be of use to him in the struggle for existence. Nor would the combination of the man's hand and the dog's brain be a more happy one. The feeble-minded and the idiotic often show but slight and unimportant physical modifications aside from those found in the brain. When looked at from the point of view of its functional relations to the whole organism, or from the point of view of its use to the possessor, neither hand nor motor nervous system alone is significant, but it is the combination of the two—the coordination—that is the important thing. And in addition to the mere manual skill arising from the steady nerves and the strong hand, the faculty of looking into the future—the acuteness and accuracy of mental vision—constitutes a valuable adjunct to the possessor of an organism whose chemical mechanisms of coordination give rise to no physical discomforts. The nervous mechanisms of coordination, as well as the chemical, will surely claim the serious attention of the student of evolution from its functional side. And it is not single structures or organs alone which become significant in evolution, but the coordination of all parts of an organism.

[3] *Proceedings of the Linnean Society of London*, Session 122, 1909–10, p. 9.

One corollary may be drawn from this main proposition. From the point of view of its function, neither the hand as a whole nor any of its parts which become of any real significance can be regarded as a unit character. In the inception of the character there must have been some changes in the nutrition of the tissues—some change in the chemical mechanism of coordination—rendering such a departure possible, and such a change in a chemical system seldom arises without some associated change in conditions, near or remote. And when the character has developed to a stage at which it becomes significant, it acquires this significance only because it may enter into correlated or coordinated activity with other parts of the organism through the medium of chemical or nervous mechanisms, or both. It is difficult for a physiologist to regard any one portion of the body as an isolated mechanism acting without reference to any other mechanism. The tendency to regard a mechanism as an isolated mechanism has often led into error. And the attempts by experimental methods completely to isolate any mechanism so that it acts independently of every other has proved to be a difficult and for the most part impossible process under present laboratory conditions. In the living animal under its various conditions of existence, coordination is an indispensable process. And since the processes of evolution are concerned with living animals rather than dead ones, the mechanisms of coordination become the important factors in evolution. For it is these internal factors which modify in greater degree than any others the growth and development of the organism in any environment in which life is possible.

That Gaskell clearly recognized the importance of coordination and insisted upon it is clear from the extract quoted above. To recognize clearly amid the multiplicity of confusing detail the fundamental factors in organic evolution regarded from its functional side, is a noteworthy achievement. And to state the problem in terms of biological phenomena rather than in metaphysical terms is to give to other biologists a fruitful working hypothesis. It is with a poignant sense of a personal as well as a scientific loss that many of us have read the recent announcement of his death. A kindly, sturdy, clear-eyed Briton, England need have little fear for the future of its science if she can produce more of his like.

F. H. PIKE

DEPARTMENT OF PHYSIOLOGY,
COLUMBIA UNIVERSITY

THE PHILADELPHIA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND AFFILIATED SOCIETIES

THE preliminary announcement for the meetings of the American Association and those of the Affiliated Societies which will meet with it at Philadelphia during the coming convocation week has now been sent to members. The arrangements for the meeting are well under way and a strong local committee has been appointed, of which Provost Edgar F. Smith is chairman, Dr. J. H. Pennimann is vice-chairman, Dr. Philip P. Calvert is secretary, and Dr. George D. Rosengarten is chairman of the finance committee.

The first meeting of the council will be held on Monday, December 28, at 9 A.M. in the council room at Houston Hall. Registration will be held from 9 A.M. to 5 P.M. each day at headquarters in the Houston Club. The sections will meet for organization at 10 A.M. on Monday and will continue their sessions during the week.

The first general session will be held in Weightman Hall, university gymnasium, at 8 P.M. on Monday, December 28. The meeting will be called to order by retiring president Edmund B. Wilson, of Columbia University, who will introduce the president of the meeting, Dr. Charles W. Eliot, of Harvard. Addresses of welcome by the provost and the governor-elect will be replied to by President Eliot, after which retiring President Wilson will deliver his address on "Some Aspects of Progress in Modern Zoology."

There will be two public lectures, complimentary to the citizens of Philadelphia and

vicinity, the one on Tuesday night, at 8 o'clock, being by Dr. Dayton C. Miller on "The Science of Musical Sounds." On Wednesday night, at 8 o'clock, Dr. William H. Nichols will lecture on "The War and the Chemical Industry." The titles of the addresses by the retiring vice-presidents of the sections, to be delivered during the week before the respective sections of the association are as follows:

Vice-president Alfred D. Cole, before the Section of Physics: "Recent Evidence for the Existence of the Nucleus Atom."

Vice-president Henry C. Cowles, before the Section of Botany: "The Economic Trend of Botany."

Vice-president Walter B. Pillsbury, before the Section of Anthropology and Psychology: "The Function and Test of Definition and Method in Psychology."

Vice-president Frank Schlesinger, before the Section of Mathematics and Astronomy: "The Object of Astronomical and Mathematical Research."

Vice-president L. H. Bailey, before the Section of Agriculture: "The Place of Research and of Publicity in the Forthcoming Country Life Development."

Vice-president P. P. Claxton, before the Section of Education: "The American Rural School."

Vice-president O. P. Hood, before the Section of Engineering: "Safety Engineering."

Vice-president Joseph S. Diller, before the Section of Geology and Geography: "The Relief of our Pacific Coast."

Vice-president Theodore Hough, before the Section of Physiology and Experimental Medicine: "The Classification of Nervous Reactions."

Vice-president Judson G. Wall, before the Section of Social and Economic Science: "Social and Economic Value of Industrial Museums."

Vice-president Alfred G. Mayer, before the Section of Zoology: "The Research Work of the Tortugas Laboratory of the Carnegie Institution of Washington."

Vice-president Carl S. Alsberg, before the Section of Chemistry: "Fermentation."

A notable event of the meeting will be the organization of the new Section of Agriculture. Vice-president L. H. Bailey will deliver his address this year, and the new section will hold its symposium at 3 P.M. on Wednesday, December 30, on the subject of "The Field of Rural Economics."

Other symposia will be held as follows: Section B and the American Physical Society at 3 P.M., Tuesday, December 29, on The Use of Dimensional Equations; Section K, at 2.45 P.M., Thursday, December 31, on the subject of Ventilation; at the same time, one will be held by Section F, the American Society of Naturalists, the Botanical Society of America and the Society of American Bacteriologists, on The Value of Zoology to Humanity; and at 11 A.M., Friday, January 1, by Sections C and K on the subject of The Rôle of Nitro-Organisms.

An unusual number of affiliated societies will meet with the association this year and will hold their sessions as indicated in another article in this issue concerning the Philadelphia meeting. The hotel headquarters will be at the Hotel Adelphia, Philadelphia's newest hotel. General headquarters will be at the Houston Club, University of Pennsylvania.

L. O. Howard

THE CONVOCATION WEEK MEETING OF SCIENTIFIC SOCIETIES

The American Association for the Advancement of Science and the national scientific societies named below will meet at Philadelphia, during convocation week, beginning on December 28, 1914:

American Association for the Advancement of Science.—President, Dr. Charles W. Eliot, Harvard University; retiring president, Professor Edmund B. Wilson, Columbia University; permanent secretary, Dr. L. O. Howard, Smithsonian Institution, Washington, D. C.; general secretary, Professor William A. Worsham, Jr., State College of Agriculture, Athens, Ga.; secretary of the council, Mr. Henry Skinner, Academy of Natural Sciences, Logan Square, Philadelphia, Pa.

Section A—Mathematics and Astronomy.—Vice-president, Professor Henry S. White, Vassar College; secretary, Professor Forest R. Moulton, University of Chicago, Chicago, Ill.

Section B—Physics.—Vice-president, Professor Anthony Zeleny, University of Minnesota; sec-

retary, Dr. W. J. Humphreys, U. S. Weather Bureau, Washington, D. C.

Section C—Chemistry.—Vice-president, Provost Edgar F. Smith, University of Pennsylvania; secretary, Dr. John Johnston, Geophysical Laboratory, Washington, D. C.

Section D—Mechanical Science and Engineering.—Vice-president, Albert Noble, New York; secretary, Professor Arthur H. Blanchard, Columbia University, New York City.

Section E—Geology and Geography.—Vice-president, Professor U. S. Grant, Northwestern University; secretary, Professor George F. Kay, University of Iowa.

Section F—Zoology.—Vice-president, Professor Frank R. Lillie, University of Chicago; secretary, Professor Herbert V. Neal, Tufts College, Mass.

Section G—Botany.—Vice-president, Dr. G. P. Clinton, Connecticut Agricultural Experiment Station; secretary, Professor W. J. V. Osterhout, Harvard University, Cambridge, Mass.

Section H—Anthropology and Psychology.—Vice-president, Dr. Clark Wissler, American Museum of Natural History; secretary, Professor George Grant MacCurdy, Yale University, New Haven, Conn.

Section I—Social and Economic Science.—Secretary, Seymour C. Loomis, 69 Church St., New Haven, Conn.

Section K—Physiology and Experimental Medicine.—Vice-president, Professor Richard Mills Pearce, University of Pennsylvania; secretary, Dr. Donald R. Hooker, Johns Hopkins Medical School, Baltimore, Md.

Section L—Education.—Vice-president, Professor Paul H. Hanus, Harvard University; secretary, Dr. Stuart A. Courtis, Liggett School, Detroit, Mich.

Section M—Agriculture.—Vice-president, Professor L. H. Bailey, Cornell University; secretary, Dr. E. W. Allen, U. S. Department of Agriculture, Washington, D. C.

The American Physical Society.—Convocation Week. President, Professor Ernest Merritt, Cornell University; secretary, Professor A. D. Cole, Ohio State University, Columbus, Ohio.

The American Federation of Teachers of the Mathematical and the Natural Sciences.—December 29. President, Professor C. R. Mann, Carnegie Foundation, New York City; secretary, Dr. Wm. A. Hedrick, McKinley Manual Training School, Washington, D. C.

The American Society of Naturalists.—December 31. President, Professor Samuel F. Clarke, Williams College; secretary, Dr. Bradley M. Davis, University of Pennsylvania, Philadelphia, Pa.

The American Society of Zoologists.—December 29–31. President, Professor C. E. McClung, University of Pennsylvania; secretary, Dr. Caswell Grave, The Johns Hopkins University, Baltimore, Md.

The Society of American Bacteriologists.—December 29–31. President, Professor Charles E. Marshall, Massachusetts Agricultural College; secretary, Dr. A. Parker Hitchens, Glenolden, Pa.

The Entomological Society of America.—December 31–January 1. President, Professor Philip P. Calvert, University of Pennsylvania; secretary, Professor Alexander D. MacGillivray, University of Illinois, Urbana, Ill.

The American Association of Economic Entomologists.—December 28–31. President, Professor H. T. Fernald, Amherst College; secretary, A. F. Burgess, Melrose Highlands, Mass.

The Geological Society of America.—December 29–31. President, Dr. George F. Becker, U. S. Geological Survey, Washington, D. C.; secretary, Dr. Edmund Otis Hovey, American Museum of Natural History, New York City.

The Paleontological Society.—December 29–31. President, Dr. Henry F. Osborn, American Museum of Natural History, New York City; secretary, Dr. R. S. Bassler, U. S. National Museum, Washington, D. C.

The Botanical Society of America.—December 29–January 1. President, Dr. A. S. Hitchcock, U. S. Department of Agriculture; secretary, Dr. George T. Moore, Botanical Garden, St. Louis, Mo.

The American Phytopathological Society.—December 29–January 1. President, Dr. Haven Metcalf, U. S. Department of Agriculture; secretary, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

American Fern Society.—December 28–29. Secretary, Charles A. Weatherby, 749 Main St., East Hartford, Conn.

Sullivant Moss Society.—December 30. Secretary, Edward B. Chamberlain, 18 West 89th St., New York, N. Y.

American Nature-Study Society.—December 30–31. Secretary, Professor E. R. Downing, University of Chicago, Chicago, Ill.

School Garden Association of America.—December 29–30. President, Van Evrie Kilpatrick, 124 West 30th St., New York, N. Y.

American Alpine Club.—January 2. Secretary, Howard Palmer, New London, Conn.

American Association of Official Horticultural

Inspectors.—December 29–30. Chairman, Dr. W. E. Britton, New Haven; secretary, Professor J. G. Saunders, Madison, Wis.

The American Microscopical Society.—December 29. President, Professor Charles Brookover, Little Rock, Ark.; secretary, T. W. Galloway, James Millikin University, Decatur, Ill.

The American Anthropological Association.—December 28–31. President, Professor Roland B. Dixon, Harvard University; secretary, Professor George Grant MacCurdy, Yale University, New Haven, Conn.

The American Folk-Lore Society.—Convocation Week. Secretary, Dr. Charles Peabody, 197 Brattle St., Cambridge, Mass.

The American Psychological Association.—December 30–January 1. President, Professor R. S. Woodworth, Columbia University; secretary, Professor R. M. Ogden, University of Tennessee, Nashville, Tenn.

The Southern Society for Philosophy and Psychology.—December 31–January 1. President, Professor John B. Watson, The Johns Hopkins University; secretary, Professor W. C. Ruediger, George Washington University, Washington, D. C.

The American Association for Labor Legislation.—December 28–29. President, Professor Henry R. Seager, Columbia University; secretary, Dr. John B. Andrews, 131 East 23d St., New York City.

Society of Sigma XI.—December 29. President, Professor J. McKeen Cattell, Columbia University; secretary, Professor Henry B. Ward, University of Illinois, Urbana, Ill.

ST. LOUIS

The American Physiological Society.—December 28–30. President, Professor W. B. Cannon, Harvard Medical School, Boston, Mass.; secretary, Professor A. J. Carlson, University of Chicago, Chicago, Ill.

The Association of American Anatomists.—December 28–30. President, Professor G. Carl Huber, University of Michigan; secretary, Dr. Charles R. Stockard, Cornell University Medical School, New York City.

The American Society of Biological Chemists.—December 28–30. President, Professor Graham Lusk, Cornell University Medical School; secretary, Professor Philip A. Shaffer, Washington University Medical School, St. Louis, Mo.

The Society for Pharmacology and Experimental Therapeutics.—December 28–30. President, Dr. Torald Sollmann, Western Reserve University Medical School, Cleveland, Ohio; secretary, Dr. John Auer, Rockefeller Institute for Medical Research, New York City.

CHICAGO

American Mathematical Society.—December 28–29. President, Professor E. B. Van Vleck, University of Wisconsin.

The Association of American Geographers.—December 29–31. President, Professor A. P. Brigham, Colgate University; secretary, Professor Isaiah Bowman, Yale University, New Haven, Conn.

The American Philosophical Association.—December 28–30. President, Professor J. H. Tufts, University of Chicago; secretary, Professor E. G. Spaulding, Princeton, N. J.

PRINCETON

The American Economic Association.—December 28–31. President, Professor John D. Gray, University of Minnesota; secretary, Professor Allyn A. Young, Cornell University, Ithaca, N. Y.

The American Sociological Society.—December 28–31. President, Professor E. A. Ross, University of Wisconsin; secretary, Professor Scott E. W. Bedford, University of Chicago, Chicago, Ill.

NEW YORK CITY

The American Mathematical Society.—January 1–2. President, Professor E. B. Van Vleck, University of Wisconsin; secretary, Professor F. N. Cole, 501 West 116th St., New York City.

SCIENTIFIC NOTES AND NEWS

In addition to the award of a Royal medal to Professor E. W. Brown, F.R.S., for his investigations in astronomy, chiefly in lunar theory, recently announced in Science, the president and council of the Royal Society have awarded a Royal medal to Professor W. J. Sollas, F.R.S., for his researches in paleontology, especially in the development of new methods; the Copley medal to Sir Joseph Thomson, O.M., F.R.S., for his discoveries in physical science; the Rumford medal to the Rt. Hon. the Lord Rayleigh, O.M., F.R.S., for his numerous researches in optics; the Davy medal to Professor W. J. Pope, F.R.S., for his researches on stereochemistry and on the rela-

tions between crystalline form and chemical constitution; the Darwin medal to Professor E. B. Poulton, F.R.S., for his researches in heredity; the Hughes medal to Professor J. S. Townsend, F.R.S., for his researches on electric behavior of gases.

DR. F. SCHLESINGER, director of the Allegheny Observatory, and professor of astronomy, University of Pittsburgh; Mr. W. S. Adams, of Mount Wilson Solar Observatory, and Professor H. Andoyer, professor of physical astronomy in the Sorbonne, Paris, have been elected associates of the Royal Astronomical Society.

PROFESSOR W. H. BRAGG, of the department of physics of the University of Leeds, has been appointed Woodward lecturer at Yale University.

DR. C.-E. A. WINSLOW has resigned from the College of the City of New York to become director of education in the reorganized State Department of Health. His work at the American Museum of Natural History will continue as heretofore.

DR. GEORGE R. LYMAN, professor of botany in Dartmouth College, has been appointed pathologist with the Federal Horticultural Board. Professor Lyman will not remove to Washington until January 1, 1915.

PROFESSOR F. T. TROUTON, D.Sc., F.R.S., has resigned the Quain chair of physics at University College, London, to which he was appointed in 1902.

PROFESSORS WALDEYER, ORTH and others have added their protests to that of Professors Foerster and Verworn against the action of Professors von Behring, Roentgen and others in melting down the medals and renouncing the honors conferred upon them by various scientific bodies in Great Britain.

THE Iron Cross has been awarded to Dr. Walther Nernst, professor of physics in the University of Berlin, who since the death of his son at the front, has joined the automobile corps.

DR. A. WESTERMARCK, of Helsingfors, Finland, and professor of sociology at the University of London, who was to have delivered a series of anniversary lectures at Brown University this winter, will be prevented by the European war from coming to this country.

PROFESSOR L. H. HARRIS, formerly associate professor of the University of Pittsburgh, has been appointed consulting engineer to the Public Service Commission of Pennsylvania.

ASSOCIATE PROFESSOR CHARLES J. CHAMBERLAIN, of the department of botany in the University of Chicago, has recently returned from a botanical trip through Florida and Cuba, continuing the investigations which have already taken him to Mexico, the Hawaiian Islands, New Zealand, Australia and Africa. The recent collecting was done in northern and southern Florida, but chiefly in the western part of Cuba, in the mountains about Herradura, Consolacion del Sur and Pinar del Rio.

PROFESSOR H. C. ADAMS, of the University of Michigan, has returned from China. He was called there one year ago to devise an accounting system for the railroads which the government had taken over. He will resume his work in the department of political economy next semester.

MR. A. FLECK, demonstrator at the University of Glasgow, has been appointed physical chemist to the Glasgow Radium Committee, established to administer a large fund collected in the city for the purpose of acquiring and distributing radium for therapeutic purposes. A radiometric laboratory, under the auspices of the committee, has been fitted up at the university.

DR. FREDERICK G. NOVY, professor of bacteriology in the University of Michigan, lectured before the Science Club of the State Normal College at Ypsilanti, on November 23, on the foot and mouth disease which is now prevalent in Michigan.

DR. JOHANNA WESTERDIJK has given five lectures before the students of plant pathology in the University of Illinois. The subjects of her lectures were as follows: Tropical Plant Diseases; Potato Vine Diseases; Potato Tuber Diseases; Fruit Diseases in Europe and America; Some Problems in Plant Pathology and Methods of Meeting Them.

During the week ending November 14, Professor George Grant MacCurdy lectured twice for the Pittsburgh Academy of Science and Art, once at Swarthmore College, and once for the Hartford (Conn.) branch of the Archeological Institute of America.

A portrait of the late Director E. A. Fuertes which was presented to the university by the alumni of the College of Civil Engineering of Cornell University was accepted by the trustees on November 7. It was resolved that, in accordance with the suggestion of the donors, the portrait hang in the office of the college in Lincoln Hall.

A bust of the late Professor Leuckart, the well-known zoologist, has been presented by his widow to the University of Leipzig.

Dr. Theodor Lipps, professor of psychology and philosophy at the University of Munich, has died at the age of sixty-three years.

Dr. Rudolf Emmerich, professor of hygiene and bacteriology in the University of Munich, has died at the age of sixty-two years.

Mr. Douglas S. Martin, at one time on the editorial staff of *The Electrical World*, who left New York in August to enroll in the mounted forces of Great Britain, has died in the Bolougne Hospital from shrapnel wounds received at the battle of Messines, on the Belgian border.

We learn that Dr. Hermann Strebel, widely known on account of his researches in anthropology and malacology, especially of Mexico, where he was long a resident, died at Hamburg, Germany, on November 6, in his eighty-first year. His scientific activities continued almost to the time of his death.

The death is also announced of Dr. J. Borgmann, professor of physics in the University of Petrograd, and author of works on electricity and magnetism.

Dr. Emile Reymond, the distinguished French surgeon and senator of the Department of the Loire, has been killed while reconnoitering in an aeroplane above the German lines. Dr. Reymond was born in 1865, the son of the eminent engineer, Francis Reymond.

The deaths of scientific men who had been with the German army at the front are announced as follows: Dr. R. Stumpf, docent and first assistant in the Pathological Institute of the University of Breslau; Dr. Franz Velisek, professor of mathematics in the Technical Institute at Prague; Dr. G. Paur, docent for statistics in the Royal Academy at Posen; Dr. Franz Marshall, director of the experimental laboratory of the Agricultural Institute of the University of Halle; Dr. Constantin Guillemaup, docent in geology in the Technical School at Aix, and Dr. Oswald Loeb, docent for pharmacology in the University of Göttingen.

The *British Medical Journal* states that the German medical staff has already suffered very severely in the present war. Up to the middle of October 135 medical officers were reported killed, wounded or missing, 74 of these having been killed. Among them is Friedrich König, professor of surgery in the University of Marburg, and son of the late Professor Franz König, of Berlin; he was killed in action at the eastern seat of war. In the entire Franco-German war of 1870–71 only 11 German surgeons died on the battlefield or from wounds there received. According to the *Berliner med. Wochenschrift* of October 19, the decoration of the iron cross had then been bestowed on 120 medical officers.

The anniversary dinner of the Royal Society, usually held on St. Andrew's Day, will not take place this year. The council of the Physical Society of London has also decided not to hold its annual exhibition of physical apparatus.

The Western American Phytopathological Society will hold a meeting at Corvallis, Oregon, on December 28, 29 and 30. This society was organized at the State Fruit Growers' Convention at Davis, California, last spring, and, while its principal aim is to discuss matters of technical plant pathology, practical

features will also receive considerable attention. All persons interested in this subject are cordially invited to attend the meetings. Further information concerning the meeting may be had by addressing the secretary of the society, Wm. T. Horne, University of California, Berkeley, California, or Professor H. S. Jackson, Corvallis, Oregon.

UNIVERSITY AND EDUCATIONAL NEWS

THE newly founded university at Frankfurt a. M. has been opened as planned, having enrolled Edinger, Ehrlich, Embden, B. Fischer, Göppert, Herxheimer, Neisser, Rehn and others. Kaiser Wilhelm is said to have signed the statutes of the university on the historic date, August 1. Austria-Hungary has also just founded a new university, the fifth in the empire. It is located at Presburg, in Hungary, about 40 miles east of Vienna. It was inaugurated with simple ceremonies on October 4.

IT will be remembered that after the fall of Louvain and the destruction of the university and its library, the University of Cambridge formally invited the Louvain professors and students to transfer their university to Cambridge, and, as far as it might prove possible to do so in a foreign land, to carry on their teaching and examining. After some time it became apparent that the authorities of the Belgian university did not see their way formally to accept. This, however, has not prevented steps from being taken for the formation of unofficial courses, which are being conducted by the following professors: Dr. Arien, Louvain; Professor Breithof, Louvain (graphics); Professor Carnoy, Louvain (Greek); Professor Colson, Liége (chemistry); Professor Corbiau; Professor Déjace, Liége (law); Dr. Devigne, Liége (law and philosophy); Professor Léon Dupriez, Louvain (law); Professor Van Gehuchten, Louvain (neuropathology); Professor Gillet; Professor Van Hecke, Louvain (engineering); Professor Canon Van Hoonacker, Louvain (theology); Professor de La Vallée-Poussin, Ghent (Sanskrit); Professor Steels; Professor Van den Ven (Byzantine Greek).

THE University of Glasgow has offered academic hospitality to accredited teachers and students of Belgian universities who have taken refuge in Glasgow. The heads of the several departments will afford them such facilities for study and research as it may be found practicable to provide.

PLANS are practically completed for the construction of the Anthony N. Brady Memorial Laboratory of the Yale Medical School. The laboratory and administration building will be erected early in the spring of 1915.

DR. JAMES ROWLAND ANGELL, who is head of the department of psychology and dean of the Faculties of Arts, Literature and Science in the University of Chicago, has declined the offer of the presidency of the University of Washington at Seattle.

MR. L. R. FORD, of Harvard University, has resigned, on account of the war, the Sheldon fellowship on which he was to have studied abroad, and has accepted a lectureship in mathematics at the University of Edinburgh.

PROFESSOR WILLIAM MARSHALL, on leave from Purdue University, has returned from Europe and has been appointed assistant professor of mathematics in the University of Arizona for the year 1914–15.

DR. RUDOLPH H. KOCHER has been appointed instructor in research medicine in the Hooper Foundation of Medical Research of the University of California, Berkeley.

DR. A. H. LOTHROP, formerly of Columbia University, has been appointed professor of biological chemistry in Queens University, Kingston, Ontario.

DR. WALTER RAMSDEN, senior demonstrator in physiology at Oxford University, has been elected to the Johnston chair of bio-chemistry at Liverpool University rendered vacant by the resignation of Dr. Benjamin Moore.

THE vacancy in the chair of chemistry of the University of Aberdeen, caused by the retirement of Professor F. R. Japp after twenty-four years' service, has been filled by the ap-

pointment of Mr. Frederick Soddy, formerly lecturer in physical chemistry and radioactivity, in the University of Glasgow; Professor Theodore Shennan, pathologist to the Royal Infirmary of Edinburgh and lecturer in the university will succeed Professor George Dean in the chair of pathology.

DISCUSSION AND CORRESPONDENCE

MINUTE ANIMAL PARASITES

To the Editor of Science: We have to thank you for inserting a review of our book, "Some Minute Animal Parasites" in your issue of July 17, pp. 105–107, and now ask the favor of your columns for the purpose of correcting certain inaccuracies contained therein. Unfortunately, the reviewer has made rather numerous inferences not to be found or suggested in the original, and seems to have mistaken an account of life-histories of certain parasitic Protozoa for a text-book of the type dear to the systematist. Both space and time prevent us doing more than indicate a few of the lapses from accuracy in the review, but mention of certain of these is essential.

The review states:

1. The fourth chapter deals with the spirochætes in a manner "which shall be as non-controversial as possible, and which will consist of facts and not the speculations so fashionable nowadays." The authors adhere so consistently to this promise that the reader would never know from the text that thousands of others have worked with these organisms.

Excluding the hyperbole regarding the thousands of workers on the subject, we quote in that chapter the works of Balfour, Blaizot, Blanc, Breinl, Certes, Conseil, Doflein, Dutton, Ehrenberg, Hindle, Leishman, Markham, Carter, Moebius, Nicolle, Perrin, Prowazek, Schaudinn, Todd, Zuelzer and ourselves, and give the opinions of other investigators also.

2. He would also look in vain for a description of the spirochæte of syphilis.

A reference to p. 86 not only gives the correct name of the organism (*Treponema pallidum*), but at least ten lines of special statement regarding it. There is also an entry in the index on p. 318.

3. The sixth chapter, dealing with coccidiosis . . . omits even a reference to coccidiosis in man.

It is regrettable that p. 117 was not noticed, for it is there stated that

> The human parasite is possibly the same as that which infests rabbits, and there is the likelihood that the eating of the livers of rabbits suffering from coccidiosis has resulted in its transference with fatal results to the human host.

There is further reference to *Eimeria stiedæ* on pp. 139–140 of the book.

4. Regarding classification, the book was never intended to be a text-book for systematists and we state definitely on p. 18 that we "select material presenting as much variation as possible . . . without reference to strict schemes of classification." There is no need, then, for adherence to taxonomy. The suggested arrangement by systematic treatment according to mode of infection is impracticable because of lack of detailed knowledge in many cases. However, the principal known modes of infection among the Protozoa, with examples, are given in the first chapter of the book, on pp. 4–10.

The ungenerous concluding remark in the review, is, we feel, best ignored. We have already mentioned in this letter the numerous authors to whose work reference is made in Chapter IV., and a similar condition obtains elsewhere. We can only say that we have endeavored to do justice to all so far as the limits of a book of this kind would allow. This fact has received outside recognition generally, and we may quote the opinion expressed in the well-known English journal *The Lancet*, June 27, 1914, p. 1819, where it is stated that

> We may note that everywhere the authors of the book under review are careful to give honor where honor is due.

In conclusion, we may add that we endeavored to appeal not only to students of science, but also to the class of educated persons whom the technicalities and terminology of the systematist have hitherto repelled.

H. B. Fantham,
A. Porter

Cambridge, England

THE REPLY OF FANTHAM AND PORTER

IT is regrettable certainly that books submitted for review do not always meet with unqualified commendation. Any such book is an objective thing to be treated critically and impartially by the unprejudiced reviewer and the impression made by the book upon the reviewer should be honestly set forth by him. This was the case in the present instance and the concluding remark which the authors feel it best to ignore, was the honest impression made by the book upon the reviewer. As it was an impression made on a reader unacquainted with the authors but familiar with the subjects discussed, the fault must lie in the book.

As for the so-called inaccuracies in the review I will not take the space here to go over the matters which led to the criticisms but will point out some misleading statements in the authors' letter. For example the rather imposing list of names in connection with spirochætes does not include such careful observers as Novy, Gross or Dobell, whose views regarding so-called longitudinal division are quite different from those of the authors. These are probably included in the "opinions of other investigators also," an example of which, in connection with spirochaetes, may be cited from page 71:

> Again, some persons have denied the existence of longitudinal division because they themselves have not observed it. Needless to say, their misfortune does not invalidate the fact of undoubted longitudinal division.

Equally misleading is the reference (2) to *Treponema pallidum*, the spirochæte of syphilis. It is true that the Index on page 318 refers to all that is given on the subject, and we quote it in full:

> The parasite of syphilis was first regarded as a spirochæte, but later was renamed *Treponema pallidum*, because the coils of the body were said to be fixed. Balfour recently has shown that *Treponema* is a "granule shedder," *i. e.*, it produces ovoid bodies just as spirochætes do. In this case it seems very probable that it is only the minuteness of the organism that prevents full knowledge of its internal structure, and that for the same reason its coils appear fixed. There are undoubted affinities between all of the organisms mentioned, and it seems far better to keep the older nomenclature and not to attempt re-classification until the life-history of each form has been fully elucidated. Building on an insecure foundation has the disadvantage of causing endless patching and emendation later, and the old saying, "More haste, less speed," is as applicable in protozoology as elsewhere (p. 86).

This certainly justifies the criticism in the original review, for even the authors would hesitate to claim that this is a description of the organism of syphilis.

GARY N. CALKINS

A FILEFISH NEW TO THE ATLANTIC COAST OF THE UNITED STATES

WOODS HOLE continues to yield most unexpected ichthyological treasures. The latest addition to the fish fauna of the region is a filefish taken in floating rockweed in Vineyard Sound on September 3, 1914, by Mr. Vinal N. Edwards, the indefatigable collector at the fishery station. The species is *Cantherines pullus*, described in 1842 from Brazil and subsequently taken in Cuba, Porto Rico and Tortugas, but heretofore unknown from the east coast of the United States. The genus *Pseudomonacanthus* Bleeker, 1866, appears to be identical with *Cantherines* Swainson, 1839; and *Pseudomonacanthus amphioxys* (Cope), known only from two young specimens from St. Martin Island, West Indies, is a synonym of *Cantherines pullus* (Ranzani).

My associate Mr. Lewis Radcliffe advises that a comparison of the Woods Hole specimen and another of the same species from Porto Rico with a specimen of the type species of this genus, *Cantherines sandwichiensis* (Quoy and Gaimard), from Honolulu discloses no valid differences. As the latter is recorded from Socorro Island, off the west coast of Mexico, and the young are pelagic, it seems not improbable that a further comparison of a series of specimens from widely separated localities will prove *pullus* to be a synonym of *sandwichiensis*.

H. M. SMITH

BUREAU OF FISHERIES,
WASHINGTON, D. C.

SCIENTIFIC BOOKS

Introductory Geology, a Text-book for Colleges. By Thomas C. Chamberlin and Rollin D. Salisbury. New York: Henry Holt & Co. 1914. Pp. xi + 708. 5¾ × 8 inches. Price $2.00.

In comparison with this latest product by geologist and printer there stands before the writer a long row of early treatises and texts in geology, American and English, dating from the early part of the last century. The contrast is great, both in matter and illustrations. These old books seem very crude and it is difficult for us to realize the limitations of scientific thought before Lyell showed the uniformity of nature's processes and laid in physical evolution the foundation for biologic evolution. Much space in the older books is used in proof of matters which are now common knowledge of educated people, and the illustrations are ludicrously poor. Even to fifteen years ago publishers tabooed photographic reproductions and regarded hand engraving as the only artistic and proper illustration. Modern photography has brought the far-away geologic and physiographic features to the secluded student, and thus qualified the aphorism that the first, second and third requisites of the geologist are travel.

From 1840 to 1860 the leading text-book in geology was that of Edward Hitchcock, which in 1860 had run to the 30th edition. The civil war distracted attention from scientific studies and for many years the only prominent book in geology was Dana's Manual, on which the older geologists now living were nurtured. Up to about 1900 the works of Dana and LeConte had fair possession of the schools. Chamberlin and Salisbury's geology in three volumes was published in 1905–1906, since which time the new books in geology and physiography "speak volumes" for the popular interest in earth science. Much of this regard may be traced to the popularizing of physiographic geology, led by Davis. The profuse photographic reproduction of natural features has been a stimulant to the magazine readers and encouragement to the authors and printers, while the commercial world has been interested through the economic study of the earth now specially emphasized by the national and state geologic surveys.

The book under review is the latest word (to-day) in general geology and probably the finest example of the bookmaker's art in works of the class. A duodecimo volume of 700 pages is made of practical size by the use of thin, fine-quality paper of medium finish. It was wise to change from the heavy, highly glazed paper used in the three-volume work and to sacrifice a trifle of the quality or clearness of the halftones and the maps, for the gain in other respects. By not wasting space on wide margins a four-inch measure is secured for the excellent letterpress. As in the larger work, the insets carry impressions on both sides. The 10-point type, wide measure, with forty lines to the page, coupled with the condensed style and brief treatment of less important topics, has produced a book of reference value in practical size for students' use. The general arrangement of the matter is in the usual order.

It will be generally conceded that the senior author has preeminence in America in philosophic geology. Consequently the book will be recognized as a very high authority, especially on the philosophic or theoretic side. As should be expected with this authorship there is much original matter, though some of the text and most of the illustrations are derived from the same authors' larger work. The text is in their characteristic terse and rather technical style. They do not attempt the impossible task of making geology simple and easy to the average college student.

No competent teacher will find in this book everything that he wishes nor all that he needs with the proper emphasis for his particular region. The body of geologic knowledge has become so vast that a single volume can do no more than generalize. The physiographic, geologic and climatic characters are so very different in the several provinces of America that no book of practical size and moderate cost can adequately present the special or local features. For example: over great areas of our northern lands the glacial phenomena are

the most obtrusive and available for study; in the Appalachian region and other mountain districts the structural or tectonic features are the more striking; in the Great Basin and over the southwestern plateaus the factor of aridity; in some districts, vulcanism; etc. The stratigraphic and paleontologic differences of the several sections are quite as important. Some one has said that the best conversation goes on in hints, and a text-book for nation-wide use must be merely suggestive on many subjects. The competent college instructor must be capable of making his own text-book for his own district. The tendency of general text-books and treatises will be to omit more and more of the elementary matter as it becomes the common knowledge of educated people, and another class of books will arise for observational and intensive study of particular provinces.

To point out minor omissions, slips or errors is both ungracious and unnecessary, and few are found in this book. One broad criticism will be made of the references to collateral literature and contemporary authors. The book does not make the mistake of loading its pages with a multitude of references. But when they are used at all they should be discriminating, impartial and up-to-date. Although there are abundant references to the publication of the U. S. Geological Survey and to the *Journal of Geology*, there are comparatively few references to other literature, and very few to articles of the last ten years. Yet the geologic literature of the last decade is large and much of it of masterly character, by eminent authorities, superseding for reference value much of the older writings. The geologists of the eastern states may feel that the book has a provincial character.

This book will be welcome to those who wish a geologic philosophy based on a scientific theory of the genesis of the globe. An admirable summary is given of the three hypotheses of earth origin; the Laplacian ("Nebular"), Lockyer's meteoritic and Chamberlin's planetesimal. The manner of the earth's origin is the basal postulate in all geophysical theories and in most geologic philosophy. On very many subjects the views of the geologist and his handling of problems must ultimately be grounded on his conception of the origin of the globe and its satellite. As all geologists up to recent years, and many of the more conservative at the present time, still hold to the discredited hypothesis of an originally incandescent globe, it will be seen that this work, like its three-volume predecessor, runs counter to many long-accepted theories and presents new and novel explanations.

In true scientific spirit and with some deference to conservatism, the authors have been fair in treatment of old theories and modest in presentation of the new views, usually setting the older thought side by side with the new philosophy. A few of the topics which have original treatment, in consequence of the new cosmogeny, are: origin and nature of the deep-seated rocks; origin of the ocean and the atmosphere; origin of the sub-oceanic and continental relief; diastrophism and mountain structure; vulcanism; duration of life; climatic changes; subdivision of Precambrian time. Ore deposits are given a fair presentation under the topic "Groundwaters." The chemic and biologic processes of the ocean are given space instead of long description of the commonplace erosional work.

The historical portion of a text-book is the most difficult to handle. Selection and condensation must be made from a vast body of paleontologic fact and from uncertain or conflicting stratigraphy. And such matter is the most difficult to keep up-to-date and to make satisfactory to the experts. In general, this matter of the book seems judicious and well balanced, but the New York stratigraphy is too old. Under the Silurian the curious mistake of Hall, Emmons and Dana in placing the Oneida conglomerate beneath the Medina, instead of above it, is repeated, although the correction was made years ago in the New York State Museum publications, and in SCIENCE.

The series of paleogeographic maps, depicting the evolution of the continent, are copied with some reduction from the three-volume work.

It would seem desirable that, for comparison, reference should have been made to the extended series of similar maps recently published by Schuchert, and also to the series by Willis; especially as the three sets of maps show very different conceptions of the ancient epicontinental seas.

This book is probably the most comprehensive, original and suggestive of any single volume in geology now printed.

H. L. Fairchild
The University of Rochester

Technical Mechanics. By Edward R. Maurer, Professor of Mechanics in the University of Wisconsin. Third edition, rewritten. New York, John Wiley and Sons, 1914.

Maurer's "Technical Mechanics," of which the first edition was published in 1903, has a recognized position among useful text-books for students of engineering. The reprints previous to the present or third edition contained few changes; but practically the whole book has now been rewritten. The aim of the author, however, remains unchanged, the words of the original preface describing the book as "a theoretical mechanics for students of engineering" being again used as applying to the present rewritten edition. It has been the author's object to "furnish an adequate course of instruction for students of engineering in one semester, five times per week." The recasting for the present work has involved not only changes in arrangement and form of presentation, but some changes in subject-matter, such as the omission of the chapter on attraction and stress and some amplification of rigid-body dynamics. The scope and order of the work are indicated by the chapter headings: Composition and resolution of forces; forces in equilibrium; simple structures; friction; center of gravity; suspended cables; rectilinear motion; curvilinear motion; translation and rotation; work, energy, power; momentum and impulse; two-dimensional motion; three-dimensional motion; appendices on theory of dimensions of units and moment of inertia of plane areas. Especially worthy of note are the twelve pages in the chapter on momentum and impulse devoted to a lucid explanation of gyroscopic action and its applications to the gyro-compass, the mono-rail car, the gyro-stabilizer for ships, and the self-steering torpedo. A wholly new collection of problems is given, most of which are collected at the end of the book, thus avoiding interruption of continuity of exposition in the text. The illustrations, more than 500 in number, are executed with notable care.

Those who know the original edition need not be told that the author's presentation is, with few if any exceptions, sound, and that a notable quality of his exposition is conciseness without sacrifice of logical accuracy or completeness. Some teachers may perhaps think the virtue of conciseness is at times carried so far as to make the book unduly difficult reading for the beginner. The many teachers who have successfully used previous editions will, however, undoubtedly find the rewritten work even more satisfactory.

In reviewing the first edition[1] of this book, the writer took occasion to discuss certain questions regarding the presentation of fundamental principles of dynamics. At the present time special interest attaches to Professor Maurer's presentation of principles because of his position as chairman of the committee on the teaching of mechanics appointed in 1913 by the S. P. E. E. The appointment of this committee seems to have been due largely to certain rather vigorous criticisms of current methods of presenting fundamental principles, especially the "fundamental equation of dynamics" and the definitions of units of force.

Professor Maurer uses the equation $F = ma$, but his explanation of it makes it seem subsidiary to the equation $F/W = a/g$, or $F = (W/g)a$; the latter equation being explained as a special case of $F/F' = a/a'$, where a, a' are the accelerations due to forces F, F' acting on the same body at different times. In order to pass from the equation $F = (W/g)a$ to the equation $F = ma$ (or $F = Kma$ if units are unrestricted) use is made of the fact that different bodies in the same locality are equally accelerated by gravity. In the view of the

[1] Science, Vol. XXI., p. 302.

present writer this procedure is not strictly sound as a scientific explanation of the equation $F = Kma$. The presence of the mass constant in the equation should rather be accepted as an ultimate part of the laws of motion, while the facts of gravity are wholly apart from those laws. This is in fact elsewhere recognized by the author in his apparent acceptance of Newton's laws (p. 155) as the scientific basis of dynamics.

Although Professor Maurer's procedure described above seems to lend some countenance to the position of those who call the equation $F/F' = a/a'$ the "fundamental equation of dynamics," it is not likely that he really accepts this view; probably his order of presentation was dictated by pedagogic considerations. An equation which results from comparing the effects of different forces *upon the same body* can not, of course, be regarded as a complete expression of the fundamental law of motion; it is equally important to compare the effects of forces *acting upon any different bodies.* This of necessity brings in the body-constant which most physicists call mass. If an equation is used which does not contain this quantity explicitly, it must be implicitly taken account of in the application.

As a matter of fact it is difficult to understand the antagonism which some critics have shown for the equation $F = ma$. The main alleged objection to it appears to be the fact that it requires units to be properly chosen; but this is true of most of the equations used to express physical laws or facts.[2] One who really understands the fundamental principle of dynamics will have no difficulty in understanding the equation $F = ma$, or in remembering that it implies that units are so defined that unit force acting on unit mass causes unit acceleration.

To the present writer it seems that the real meaning of the fundamental equation of dynamics is most clearly brought out by presenting it first in the form of a compound proportion,

$$\frac{a}{a'} \equiv \frac{F}{F'} \cdot \frac{m'}{m},$$

in which a is the acceleration due to a force F acting on a mass m and a' the acceleration due to a force F' acting on a mass m'. From this it is easy to pass to the equation $F = Kma$ for any arbitrary set of units, and then by a certain choice of units to the equation most commonly used because simplest, $F = ma$. Substantially this method of presentation was given in the first edition of Professor Maurer's book, but seems to have been omitted from the present edition.

As regards units of force, Professor Maurer's practise is the usual one among engineers. For ordinary use the pound-force or kilogram-force is adopted as unit, with the explanation that although this unit varies with locality, the variation is so slight as ordinarily to be of no practical importance. Although remarking that the pound-force can be made definite by specifying a standard locality, the author does not urge the general adoption of such a standard unit, but follows common scientific usage in adopting a kinetic definition of the absolute unit of force. This definition is, of course, based upon the fundamental principle of which the equation $F = ma$ (or $F = Kma$) is an expression. This principle being assumed, it is possible to define the unit force as that force which would give some definite mass some definite acceleration; the common practise being to take as unit the force which gives the (arbitrarily chosen) unit mass the (arbitrarily chosen) unit acceleration,[3] thus

[2] It is true, for example, of the equation usually employed to express the law of gravitation. It is true also of the simple equation $A = L^2$, where A is the area of a square of side L. In fact it is not easy to cite equations practically used in applied mathematics of which it is not true. The only way to avoid the alleged objection is to throw every such equation into the form of a proportion.

[3] It is worthy of remark that the advocates of the adoption of a standard pound force, though ostensibly defining it as the weight of a pound body at a standard locality, in reality define it as the force which would give a pound body (meaning a body whose mass is a pound) the acceleration 32.1740 ft./sec^2. Thus the real definition is of the same kind as that of the dyne, and the standard pound-force is really a "kinetic" rather than a "gravity" unit.

reducing the fundamental equation to its simplest form $F = ma$. The author points out also that it is possible to vary the procedure by choosing arbitrarily the unit force and adopting a kinetic definition of the unit mass; and he uses the word "slug" to designate the mass to which the pound-force would give an acceleration of 1 ft./sec^2. His explanation of this matter seems to the writer to be entirely sound, as well as being an aid to the student in acquiring a clear understanding of the fundamental law.

The entire treatment of force and of the laws of motion is notably free from the vagueness which too often characterizes the exposition found in text-books. The words push and pull are freely used, and the fact is explicitly stated at the outset that every force is exerted *by* one body *upon* another body. The law of action and reaction is stated in the following words: "When one particle exerts a force upon another, then the latter exerts one upon the former; and the two forces are equal, colinear and opposite." Most of the difficulty that arises over this law is due to losing sight of some one or more of the facts that are here explicitly stated. If it is kept clearly in mind that an action and its reaction (*a*) always concern two bodies and only two and (*b*) never act upon the same body, there is little difficulty in avoiding the confusion that is often associated with such terms as "inertia-force" and "kinetic reaction."

L. M. Hoskins
Stanford University

Principles of Electrical Measurements. By Arthur Whitmore Smith. New York: The McGraw-Hill Book Company, 1914. Pp. xiv + 343.

In a laboratory course, emphasis may be laid by one teacher on manipulation and details of apparatus and, by another, on the principles underlying the methods employed in making the measurements. Professor Smith does the latter and has developed a text that is suitable for classroom as well as laboratory. The book is written for the instruction of those who are beginning their course in electrical engineering or who desire a more complete understanding than is afforded in most elementary manuals. It shows thoroughness and care in its preparation. In addition to a discussion of subject-matter usual in a laboratory manual of this kind—as ammeter and voltmeter methods; use of the galvanometer, bridge and potentiometer; measurement of current, power, capacity and inductance; magnetic tests of iron and steel—the author includes chapters on electromagnetic induction, on the definition of the Maxwell and on alternating currents, which, while not essential for one only interested in the taking of readings, lead the student to a better understanding of the subject as a whole.

Frederick Bedell

A Manual of Bacteriology for Agricultural and Science Students. By Howard S. Read. Ginn & Co. $1.25.

This little manual of 179 pages contains a collection of experiments, descriptions of methods, formulæ for media and reagents, and other information of practical use in a bacteriological laboratory. It is intended as an outline of a course for students, but it would be quite difficult, indeed, practically impossible, in an ordinary laboratory, for a student to follow this course consecutively, since the experiments described follow each other in an order that, while logical for study, would be almost impractical to carry out in a laboratory class. As a result the student can not follow the course without very careful thought and selection of experiments on the part of the teacher. The book is therefore more valuable for a manual for reference than as a distinct course for students to follow. It contains large numbers of experiments, and if properly used can be made of great use as a foundation of a course in bacteriology. It is more complete, more up-to-date, and contains more of the recent additions to bacteriological methods than the other manuals which have been published in the last few years. It is made more valuable by having in addition to methods strictly bacteriological some which are especially designed for the study of yeasts, and of common molds. While the methods are

in general simply described, in some cases difficult technique is passed over with a few words of description, so meager as to make it almost impossible for the student to follow them without very close supervision on the part of the instructor. For example, it is doubtful whether a student could ever obtain a pure culture of yeasts by the method described without having an instructor at hand to show him every detailed step. The numerous experiments also imply the possession on the part of the instructor of a large amount of material commonly not at hand in a bacteriological laboratory, especially in the way of cultures of various organisms, and no direction is given as to how these may be obtained.

In a little book of this kind not all laboratory methods can be included, and some omission may be well excused. Some of the omissions are a little unfortunate. For example, in describing the detection of nitrites, the method that is commonly used, of inoculating bacteria into nitrate broth is not given at all, the only method given depending upon synthetic media. The common use of nitrate broth, included in the standard methods, should certainly have been among the methods given in this little manual. On the whole, the manual is useful, and can be recommended as an up-to-date reference book of laboratory methods.

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The Elements of Psychology. By DAVID R. MAJOR. Revised Edition. Columbus, R. G. Adams & Co. 1914. Pp. 413.

Much difficulty has been experienced in recent years in preparing a satisfactory text for introductory college courses in psychology. Possibly the difficulty arises from the fact that the customary elementary course in psychology—unlike that in other sciences—aims less to initiate the student into the use of a set of special methods and a body of knowledge obtained by their application, than to interpret and rationalize what everyone is more or less acquainted with from common experience. Evidently more tact and literary skill are required to treat what is already familiar in a profitable way, than to launch out into what is new to the student. However this may be, there have certainly been a large number of attempts to meet the felt need for an elementary text, and few of the attempts have given much satisfaction. The present book is another experiment in this direction, and appears likely to prove unusually successful. If it makes no great claim to originality of teaching, and has no special axe to grind, and if it lacks somewhat in incisiveness, these are defects which the student can readily overlook in view of its well-sustained effort to meet him on his own ground. Granted that the introductory course is to be kept within its traditional bounds, this text should make a very satisfactory guide.

R. S. WOODWORTH

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SCIENTIFIC JOURNALS AND ARTICLES

Terrestrial Magnetism and Atmospheric Electricity for December contains the following articles: "The Free and Forced Vibrations of a Suspended Magnet" (concluded), H. F. Reid; "Magnetic Declinations and Chart Corrections obtained by the *Carnegie* from Bahia, Brazil, to St. Helena, May 20 to June 22, 1913," L. A. Bauer and W. J. Peters; "On Certain Matters relating to the Theory of Atmospheric Electric Measurements," W. F. G. Swann; "Investigation of Certain Causes Responsible for Uncertainty in the Measurement of Atmospheric Conductivity by the Gerdien Conductivity Apparatus," C. W. Hewlett; "Magnetic Declinations and Chart Corrections obtained by the *Carnegie* from Hammerfest, Norway, to Reykjavik, Iceland, and thence to Brooklyn, New York, July to October, 1914," L. A. Bauer and J. P. Ault; Letters to Editor: "Principal Magnetic Storms recorded at the Cheltenham Magnetic Observatory, July–September, 1914," O. H. Tittmann; "Umbau an dem Schulze'schen D-Variometer des Observatoriums in Tsingtau," B. Meyermann.

NOTES ON METEOROLOGY AND CLIMATOLOGY

MOUNTAINS AND WINDS

A RECENT paper by Th. Hesselberg and H. U. Sverdrup, entitled, "Über den Einfluss der Gebirge auf die Luftbewegung längs der Erdoberflache und auf die Druckverteilung,"[1] includes studies of the Appalachians, Alps and Apennines as influencing winds. For the United States 51 weather maps in 1906 were chosen for study. The winds of the Appalachian region exhibit three simple types of influence. (1) With a general flow of air from the northwest there is divergence on the windward side and convergence on the leeward side of the mountains. (2) With a southeast wind there is the same general flow of air around the mountain mass but locally there are converging winds on the windward side. This is said to indicate an air whirl on a horizontal axis there. (3) When there is a general southwest wind parallel with the mountain chain, the winds over the mountains are usually across them from the west. But when the flow is from the northeast, there are no such corresponding winds crossing the mountains. These cross west winds are apparently due to the influence of the upper prevailing westerlies.

Stronger and more complex, mountain influence on crosswise and lengthwise winds was found in Europe, both because of the greater altitude of the mountains and because of more observing stations. With strong cross-mountain flow of air the atmospheric pressure is raised to windward and lowered to leeward, in addition to changes wrought in the wind direction. Cool, wet weather to windward and warm dry weather to leeward followed as a result of the dynamic changes in temperature experienced by the wind in crossing the mountains. In winter locally the mountains become high-pressure, divergence points; while over the valleys low pressure and convergence is the rule. In summer the weather maps indicate a partial reversal of these conditions, since frequently by the time the observations are taken, the diurnal heating of the valleys has already started the up-valley breezes. Thus the wind directions in and about a mountain region are strongly controlled by the presence of the mountains.

[1] Veröff. des Geophys. Inst. d. Univ. Leipzig, 2te Serie, heft 4, Leipzig, 1914, pp. 102–116, 2 pl.

THE INFLUENCE OF METEOROLOGICAL CONDITIONS ON THE PROPAGATION OF SOUND

THIS study by Dr. H. Bateman[2] includes the effects of wind, temperature, moisture and air composition on the propagation of sound. The general influence of any wind is to reduce the audibility of sounds. The usual greater range of a sound with the wind than against it is ascribed to the increase of wind velocity with altitude, which bends upward the sound waves traveling against the wind and downward those going with the wind. On the other hand, if the upper wind is opposite to the lower one, a sound refracted upward in traveling against the surface wind may be bent to the earth again on entering the other current. This may account for the peculiar regions of silence and sound often observed in easterly surface winds. If the transition from one air current to another is sharp, the boundary may become a reflecting surface.

The temperature effect on sound is much like that of the wind. In the daytime, the normal vertical decrease in temperature leads to refraction of sound waves upward, and the lack of thermal homogeneity of the air aids in dispersing sounds. At night or in cloudy weather, when the temperature is more uniform, sounds are more easily heard. Apparently the lower surface of the stratosphere acts as a reflecting surface which returns to earth heavy sounds such as from artillery fire or volcanic explosions, making spots where such sounds are heard far beyond the limits of direct audibility.

Sounds entering moist masses of air are weakened by "stifling," refraction, scattering and perhaps reflection. Fog usually produces peculiar sound effects, probably on account of temperature differences in the fog

[2] *Monthly Weather Review*, May, 1914, pp. 258–265, 1 fig.

and perhaps also because of sound reflection from the upper limit of the fog. Local interference resulting from such reflection may explain the silent regions so commonly observed in connection with fog signals.

In a similar way, the boundaries between air bodies of different temperatures and humidities in thunderstorms are important in prolonging thunder[3] and in preventing the sound from traveling great distances.[4]

THE THUNDERSTORM AND ITS PHENOMENA

PROFESSOR W. J. HUMPHREYS under the above title has published[5] a careful summary of the present knowledge relative to thunderstorm physics and has added many new points. Professor Humphreys recognizes five types of thunderstorms, which occur as follows: (1) in regions of high temperature and nearly uniform pressure (heat thunderstorms); (2) in the southeast quadrant of an almost circular cyclone; (3) between the branches of a V-shaped cyclone; (4) in the trough between two anticyclones; (5) on the boundary between warm and cold waves. All but the first are produced essentially by the over- and under-running of winds of different temperatures, which in some way cause moist air masses to rise. Each of these types is illustrated with a set of three successive weather maps at 12-hour intervals.

The squall-wind associated with thunderstorms is thought to be the outward flow from a cataract of air which is cooled and kept cold in its descent by the rain or hail falling through it. The sudden rise in air pressure at the onset of a strong thunderstorm is ascribed to the combined effect of the downward thrust, greater density and relatively small absolute humidity of this cold wind, and to the interference which the thunderstorm offers to the free flow of the general winds.

The splitting of raindrops in falling through the ascending air currents characteristic of thunderstorms is, according to G. C. Simpson, the source of the lightning. The small drops with negative charges go up with the wind while the larger ones with positive charges stay below. Thus in a thunderstorm there is usually a region of positive electricity between the negative earth and the negative upper portion of the cloud. When the charge becomes sufficient to ionize a path through the air, a series of direct current discharges usually take place along approximately the same line. A progressive lengthening of a lightning streak in its successive six discharges is shown in a picture taken with a rotating camera (Fig. 26). Professor Humphreys is to be congratulated on his thorough and simple presentation of such a difficult subject.

RAINDROP VELOCITIES[6]

J. LIZNAR in deriving a new mathematical formula for determining the velocities of raindrops has included the effect of the viscosity of the air and friction on the horizontal expanse of the drop. This formula is

$$v = 602.6\sqrt{r} + 57.013 - 73.291r^2,$$

where v is in cm. per sec., r in mm. and atmospheric pressure at 986.6 mb. (740 mm.). Applied to hail this formula becomes

$$v = 20.795(\sqrt{722.2r + 1/r^3} - 1/r).$$

The velocities of raindrops of the radii indicated are roughly as follows:

r 0.5 mm., v 400 cm. per sec.
r 1.0 mm., v 600 cm. per sec.
r 1.5 mm., v 700 cm. per sec.
r 2.7 mm., v 800 cm. per sec. (maximum).

Large drops are retarded by flattening in the air. According to Wiesner's observations this flattening of falling drops will cause those of 3.6 mm. radius to form rings and split into smaller drops.

NOTES

THE June number of the *Monthly Weather Review*, which appeared early in October, has more than 100 pages (quarto), which are devoted mostly to meteorological articles. The

[3] W. Schmidt, *Meteorologische Zeitschrift*, January, 1914, pp. 33–37.

[4] W. J. Humphreys, *Monthly Weather Review*, June, 1914, p. 379.

[5] *Ibid.*, pp. 348–380, 28 figs.

[6] *Meteorologische Zeitschrift*, July, 1914, pp. 339–347.

amount and quality of the meteorological material published in the first six numbers amply justifies the change of this periodical back to its position as the national meteorological magazine.

The daily weather maps of the northern hemisphere issued by the Weather Bureau were discontinued on August 6 on account of lack of European weather reports.

The European meteorological magazines are still being received regularly, although late.

"The Clouds of California," an address by Dr. Ford A. Carpenter before the Occidental College, has been published.[7] The discussion concerns not only the cloudiness of California, but also includes information about the composition and formation of clouds.

W. Bieber[8] has introduced a new factor to explain the blue of the sky. According to him, the action of ultraviolet light forms $NH_4NO_2 + H_2O$, a thin bluish fog in the stratosphere. The blue of the sky is also ascribed to the action on light of dust particles, exceedingly small, snow crystals, air molecules, water vapor and ozone. Recent observations on high mountains show the presence of sufficient ozone alone to account for the sky color.[9]

In Symons's *Meteorological Magazine* for several months there has been a discussion of unusual visibility of distant objects as a prognostic of rain. Haziness is due to the amount and visibility of the dust and other particles in the air and to optical disturbances caused principally by temperature differences. So the cloudiness usually preceding rain reduces dust haziness by cutting off the bright illumination of the particles, and reduces the optical haze by preventing the unequal heating of the lower air and the establishment of convectional currents. However, wind blowing from the direction of a city, which may be even far away, generally makes the air more hazy.[10]

"British Rainfall, 1913" contains rainfall returns from 5,370 stations during the year. Complete daily records were received from 3,370 stations and less complete daily returns from 364 others. For the stations sending these daily records, the density for the British Isles is roughly 42 per 1,000 square miles. The January, 1914, issue of *Climatological Data for the United States by Sections* includes daily rainfall records from 4,391 stations. Thus for the United States, as a whole, the number of rainfall stations is but 1.4 per 1,000 square miles. Even Rhode Island, the state with greatest density of rainfall stations, has but 8 per 1,000 square miles. Nevada has 0.6 for the same area. It is little wonder that the climatic maps of the United States are lacking in detail as compared with the British ones.

Charles F. Brooks
Bureau of Plant Industry,
Washington, D. C.,
October 26, 1914

[7] 18 pages. See *Nature*, London, August 6, 1914, p. 592.

[8] *Meteorologische Zeitschrift*, July, 1914, pp. 358–359.

[9] See *Scientific American Supplement*, September 19, 1914, p. 179.

[10] See *Nature*, London, August 6, 1914, p. 592.

SPECIAL ARTICLES

SOME PHYSICAL PROPERTIES OF THE CELL NUCLEUS

Investigations on the physical properties of protoplasm have received fresh impetus through the introduction by Kite[1] of Barber's pipette holder for dissection purposes. By means of fine glass needles manipulated in this holder it is possible to undertake the dissection of fresh tissue under the highest magnification of the microscope.

My results in cell dissection largely substantiate Kite's general statements on the consistency and physical make-up of protoplasm. In this paper I wish to present the results of studies made on the nucleus of the male germ cells of the grasshopper, *Disosteira Carolina*,

[1] G. L. Kite and Robert Chambers, Jr., "Vital Staining of Chromosomes and the Function and Structure of the Nucleus," Science, N. S., XXXVI., p. 639, 1912; G. L. Kite, "Studies on the Physical Properties of Protoplasm," *Am. Jour. Phys.*, XXXII., p. 146, 1913.

and of the cockroach, *Periplaneta Americana*. The follicles of the testis are isolated under the dissecting microscope and, on tearing the follicular envelope, the cells are set free. A good medium appears to be diluted Ringer's fluid to which has been added a trace of egg albumin. For the cells of the cockroach I used the body fluid collected by means of a capillary pipette. As the cells are very susceptible to mechanical stimulation care is necessary in these preliminary manipulations.

An uninjured, normal, isolated spermatocyte when not in division assumes a spherical shape. The nucleus occupies the center of the cell and, during the growth period, appears almost perfectly hyaline. In *Disosteira* three bodies stand out in the nucleus, their indices of refraction being different from that of the surrounding medium. One of them is rather elongated and lies immediately under the nuclear membrane. The other two are more or less globular and frequently lie well within the substance of the nucleus. In the cockroach only one such body or nucleolus is apparent.

Occasionally nuclei are met with in which may be discerned a mass of hazy filaments of very ill-defined outlines. It is possible that these are nuclei which have been unduly stimulated in teasing the tissue. Other nuclei are also discernible in which hazy bodies, the prophase chromosomes, are to be recognized scattered throughout the substance of the nucleus. In cells undergoing division the chromosomes are plainly visible during the meta- and anaphases.

Injury and frequently mere mechanical agitation of the cell produces a remarkable change in the appearance of the nucleus. The hitherto optically structureless nucleus begins to give evidence of hazy filament of a loose granular aspect. They lie immediately under the nuclear membrane and one gains the impression that they are produced by a lineal condensation or precipitation of granules in the hyaline nuclear substance. Within a few minutes the filaments become more distinct and thicken as the granules appear closer together. Free ends are soon to be noticed and one may occasionally trace a filament from one end to the other throughout its irregular winding course. They can not, however, be counted because they are hopelessly entangled. A light line down the middle of the filaments gives them the appearance of being longitudinally split. The granules are collected in bunches all along the length of the filament, giving it a cross striated effect. In those filaments which can be seen on end the granules are found to be arranged more or less regularly about a hyaline core. Such a structure may explain the longitudinally split appearance of the filament when viewed on the side.

The nuclear substance is a more solid and viscous gel than the cytoplasm. The filaments are still more solid and may be caught in the middle with a needle and drawn out into an attenuated loop fully as long as the diameter of the nucleus. On being set free the filament tends to retract and to thicken again. After the nuclei under observation have reached this stage the filaments collect on one side of the nucleus, and despite all my attempts to prevent it, coalesce into an irregular gelatinous mass.

The above changes take place in a period of five minutes to half an hour. Tearing of the cytoplasm of the cell accelerates the process and my conclusion is that the greater the amount of injury the more rapidly do the filaments form. In many cases the tearing causes the cytoplasm to absorb water and to go into solution. In the nuclei of cells so treated the formation of filaments takes place very rapidly.

The cells may be similarly stimulated by exposure to ether vapor. The nuclear filaments and the chromosomes then stand out clearly. Formalin vapor, on the other hand, seems to kill the cells without bringing into evidence the nuclear structure.

The stimulus produced by injury may be transmitted from the injured cell to a sound one if there be a cytoplasmic connection between the two. This is to be seen on piercing one of the daughter cells in the very late telophase of the spermatocyte. Near the end of

this stage the two daughter cells are connected with one another only by a narrow bridge of cytoplasm. Injury to the one causes the appearance of filaments in the nuclei of both. The changes in the nucleus of the cell directly injured take place more rapidly than do those in the nucleus of the other cell.

The formation or coming into evidence of the filaments is always accompanied by a slight increase in the size of the nucleus. After the filaments are formed the nucleus decreases in size often to something less than its original size.

The filamentous structure can be easily destroyed. For example, on sucking the entire nucleus containing filaments and nucleoli into a capillary pipette the bore of which is many times smaller than the diameter of the nucleus and on blowing it out again the nucleus presents itself as a homogeneous, glutinous mass with no structural elements whatever.

Frequently one comes across a cell the mechanical stimulation of which causes the appearance in the nucleus of ill-defined granular condensations which rapidly resolve themselves into the early prophase chromosomes familiar to investigators in fixed material, viz., crosses, rings and double V's. The ragged outlines characteristic of this stage are very pronounced and are due to the irregular granular aspect of the chromosomes. Gradually as one watches them the chromosomes become more and more compact. This appears to be due to an increase in the number of the granules and their coalescence. The large slender rings have thus been observed to transform themselves into ringlike, compact and homogeneous metaphase chromosomes. The crosses also become compact without losing their cross-like appearance. The same is true of the double V. One of these was observed which shortened and became so compact as to appear like a tetrahedron of which two opposite sides were somewhat more deeply dug out than the others.

This artificially induced formation of the chromosomes is unaccompanied by the dissolution of the nuclear membrane. The chromosomes soon clump together and become indistinguishable in an irregular glutinous mass. They are extremely viscous and adhere to the needle when touched. If one of the early prophase chromosomes with ragged granular outlines be seized by the needle and rapidly pulled across the field so as to stretch it the granules disappear and the whole substance becomes homogeneous. The entire nuclear substance is very glutinous and the chromosomes can not be taken out of the nucleus entirely free of the medium in which they lie. When torn out of the cell, however, in Ringer's fluid, the nuclear substance very soon absorbs water, swells and gradually disappears. The chromosomes thus laid bare in their turn swell and go into solution.

The chromosomes in metaphase are plainly visible. Movements while in the equator have been observed, these are ameboid, consisting in a swelling of one part of the chromosomes at the expense of another. One arm of a cross, for instance, will swell until the cross shape is indistinguishable and in another few seconds the swelling will decrease, the chromosomes returning to their original shape. I was unable to observe actual splitting of the chromosomes, but anaphase figures passing into telophase were frequently observed. The chromosomes collect at the poles of the spindle. They then swell into vesicles which appear to merge into each other much as fluid droplets, except that here incomplete outlines of the vesicles persist for a time giving the telophase nucleus an ill-defined network appearance.

During metaphase and anaphase the chromosomes lie imbedded in a hyaline substance the viscosity of which is higher than that of the surrounding cytoplasm, much resembling the matrix of the resting nucleus. This kinoplasmic mass retains its shape for a time after the cytoplasm has been destroyed by tearing and it is this that gives the characteristic spindle shape of the metaphase and hour-glass shape of the late anaphase figures.

When once the chromosomes have separated in metaphase, no interference short of total destruction of the cell will prevent the passage of the daughter chromosomes to their respective poles. By piercing and tearing the cytoplasm in the equator of the anaphase figure,

the constriction in that region may be so inhibited as to cause the two daughter cells to reunite into one spherical cell but the daughter nuclei remain separate.

As this paper is concerned only with intranuclear structures I shall merely mention here that the mitochondrial threads characteristic of the orthopteran germ cell form the boundary of the kinoplasmic mass and give it an appearance of being composed of threads. I have been unable to ascertain the existence of spindle fibers. The chromosomes may easily be pulled out of the equatorial plate and give no evidence of being attached to such fibers. When one chromosome is dislodged from the equatorial plate the others leave their places, and if left to themselves, clump together into an irregular homogeneous mass.

A curious phenomenon connected with the dissolution of the cells is the production of long slender processes which radiate in every direction from the surface of the cells. The ends of the processes soon grow into rounded knobs which gradually increase in size and often break off in the form of droplets. These droplets rapidly go into solution. Within half an hour or so, however, the entire protoplasm of the cell takes up water and swells. The pseudopodia are then slowly retracted and the cell rounds up and may remain so for a long time.

During the first stages of their formation the pseudopodia occasionally perform irregular oscillatory movements. Their formation is similar to that of sea-urchin eggs when subjected to the cytolytic action of diluted KCl solution. Similar phenomena have been described by Kite[2] and Oliver[3] and Merk[4] in blood cells. Chromosomes show the same phenomenon when isolated in Ringer's fluid. In one case which was very striking a ring chromosome was removed from the equatorial plate. Within two minutes a pseudopod began to appear from one side of the ring. Within five minutes this had lengthened into an attenuated filament which oscillated slowly. The attenuated tip gradually resolved itself into a knob which soon was pinched off in the form of a droplet. By the time a second droplet was formed and pinched off the chromosome itself began to swell and rapidly went into solution.

According to the foregoing experiments the chromosome appears to be a highly viscous and glutinous protoplasmic gel readily swelling in water and possessing very much the same physical properties as the cytoplasm of the cell.

ROBERT CHAMBERS, JR.
UNIVERSITY OF CINCINNATI,
October, 1914

[2] G. L. Kite, "Some Structural Transformations of the Bloodcells of Vertebrates," *J. Inf. Diseases*, XV., p. 319, 1914.

[3] SCIENCE, N. S., XL., p. 645, 1914.

[4] *Arch. f. Mikr. Anat.*, 80, 1912.

THE GEOLOGIC HISTORY OF LAKE LAHONTAN

THE basin of the great lake that once covered much of western Nevada has been classic ground ever since the early geologists first studied it. The shore lines which are to-day practically as the receding waters left them, the calcareous deposits about its basin, the possibility of saline deposits of commercial importance, have made the deciphering of its history one of the goals of geologic endeavor. King,[1] believing all of the tufa was a pseudomorph after gay-lussite and witnessing the formation of the latter in the Soda Lakes, believed that Lahontan had become as saline through desiccation, had then fallen, depositing the tufa as gay-lussite, and that a second flooding of the lake had caused it to overflow, washing out the saline material and changing the tufa to calcite.

Russell[2] determined that Lahontan had never had an outlet and thereby vitiated King's hypothesis. Believing that the tufas were a deposit from waters saturated with calcium carbonate and taking his clue from the Great Salt Lake, Russell assumed that the waters of Lake Lahontan must have been equally saline, although much of his evidence

[1] King, Clarence, U. S. Geol. Expl. of the 40th Par., Vol. 1, p. 522.

[2] Russell, I. C., Monograph No. 11, U. S. Geological Survey, 1885.

indicated otherwise. Finding the lakes at present occupying portions of the basin to be comparatively fresh, he believed that Lahontan had been completely desiccated and its saline deposits buried before the present lakes formed.

Russell recognized three types of the tufa in the Lahontan Basin; the lithoid, stony and compact; the dendritic, porous and coralline; and the thinolite, crystallized and a pseudomorph after an unknown mineral. For a distance of one hundred feet above the present level of Pyramid Lake these were found to be superimposed, the lithoid at the base, succeeded by the thinolite, and the dendritic covering the other two. While he recognized that there was some lithoid tufa intermingled with the dendritic, he believed that the lithoid had been deposited from waters of slightly different composition from those forming the dendritic tufa. Finding a medial series of gravels in the lake sediments, he believed that Lahontan had formed, diminished through desiccation and deposited the lithoid tufa, had again risen nearly to its former level, had again been desiccated, depositing the thinolite and dendritic tufas and, completely disappearing, left the other salts to be buried beneath the alluvium that swept in from the surrounding mountains. Later a slight change to a more humid climate produced the present lakes.

In the course of work in the vicinity of the Salton Sea,[3] done in connection with Dr. D. T. MacDougal, director of the desert laboratory of the Carnegie Institution of Washington, it was concluded that the tufa at present forming in the sea were being deposited through the activities of blue-green algæ and the bacteria associated with them. The more significant evidence discovered was the constant association of the algæ and the tufa, the extreme localization of the tufas, the formation of the tufa from water that contained considerably less calcium carbonate than would saturate it, and the evident relation between the development of the tufa and the light exposure. Further, a gradual gradation between the dendritic and the lithoid tufas was found in the older tufas of the basin, the lithoid tufa being formed in the dark portions of recesses in the cliffs where the conditions were unfavorable for the normal growth of the algæ. Thin sections of the older tufa show abundant remains of the algæ included in the tufa as are the algæ in the tufa forming at present.

Through the kindness of Dr. MacDougal it was possible to immediately carry the study in to the Lahontan Basin. Around the shores of Pyramid Lake a thin coating of lithoid tufa was found coating the rocks and in places cementing the gravels. The same close association between the algæ and the tufa was observed, and wherever the algæ were found the gravels were cemented and where they were absent no trace of the tufa could be found. Thin sections of the older dendritic tufa disclosed forms similar to those found in the tufas of the Salton Basin and sections of the tufa forming at present showed the algæ imbedded in it. As analyses of the lake water showed it to contain only about one twentieth the calcium carbonate necessary to saturate it, it is evident that the tufa forming to-day is being deposited through the activities of the plant life. As the algæ in the Salton Sea are depositing dendritic tufa from waters containing ten times more calcium carbonate than Pyramid Lake and the tufa being deposited in the latter at present is lithoid in type, it is probable that the calcium content of the lake waters is a determining factor in the type formed.

In the Lahontan Basin a thin layer of the lithoid tufa is in immediate contact with the rocks on which deposits of tufa were formed. Approximately six inches in thickness near the water's edge it decreases in thickness until at the top it merges with the caliche formed on the basalt that is the predominant rock in the basin, and it is practically impossible to say just where the tufa ends and the caliche begins. The dendritic tufa is best developed in a horizontal zone between one and two hundred feet above the present lake. It gradually diminishes in thickness and changes character

[3] Jones, J. C., Pub. No. 193, Carnegie Inst. of Wash., pp. 79–83, 1914.

until at the higher levels it merges with the lithoid tufa. In other words, the gradation between the lithoid and dendritic types in the Lahontan basin is a vertical one and was apparently caused by the increasing calcium carbonate content of the receding lake waters.

Russell placed the upper limit of the thinolite tufa at the thinolite terrace now one hundred feet above the lake. During the present study it was found that the thinolite extended some forty feet above the terrace throughout the Pyramid Basin and there ended in a few scattered crystals at the base of the dendritic tufa. Dana[4] after a careful study of the thinolite crystals came to the conclusion that it was a pseudomorph after an unknown tetragonal mineral, possibly a chlor-carbonate of calcium. Measurements by the writer of some of the more perfect crystals lead to the conclusion that the original mineral was orthorhombic and probably aragonite. On experimentation it was found that when a saturated solution of calcium carbonate was added to the water from Pyramid Lake minute crystals of aragonite closely resembling in their detail the smaller crystals of the thinolite separated after standing a day or two. The thinolite, therefore, was deposited as aragonite at a time when the waters of Lahontan were saturated with calcium carbonate.

As was recognized by Russell, the intermediary gravels are bar and beach deposits, and as only the lithoid tufa is associated with them they represent a low water stage in the filling of the basin.

To sum up the present evidence the broader features of the history of Lake Lahontan are believed to be as follows. As the Lahontan Basin began to fill the waters approximated those in the present rivers flowing into it and contained but little calcium carbonate. As a consequence the algæ as they became established on the rocks about the lake were able to deposit only the lithoid tufa. With the climax of the lake when evaporation became the controlling factor and the lake diminished the relative amount of calcium carbonate present increased more rapidly than the algæ could remove it. With the increasing amount of calcium available the type of tufa deposited gradually changed to the dendritic. Nevertheless, the calcium continued to increase until when the lake had fallen three hundred and fifty feet from its highest level, the waters were saturated and the surplus was deposited as aragonite forming the thinolite tufa. With the removal of the surplus calcium and probably aided by the slower fall of the lakes, owing to the diminished area the algæ caught up and have removed the calcium faster than it was brought in by the rivers until at the present time the lake contains only one twentieth the amount of calcium possible and only the lithoid tufa is being deposited.

As there is little or no evidence of an unconformity in the tufas, they in themselves do not indicate more than one lake period. The intermediary gravels are all above the present level of the lakes and from such evidence as has been gathered represent but a low water stage in the early filling of the lake basin. With the conclusion that Lake Lahontan had but a single period of extreme high water the question naturally arises as to whether the lake has completely disappeared.

One unfamiliar with the area and reading the reports of King and Russell is apt to gather the impression that a large part of the basin is covered by the tufa. This is not correct. As was noted by Russell, the tufa is extremely localized and occurs for the most part in large isolated masses. It is only the narrow band of recent tufa about the present shores of Pyramid Lake that approaches a continuous layer and it probably covers less than fifty per cent. of the shores exposed. A liberal estimate of the tufa-covered area of the basins of Pyramid and Winnemucca lakes is one per cent. of the total area of these basins and the tufa is much more abundant here than in the remainder of the Lahontan Basin. Estimating an average thickness of eight feet of tufa below the Thinolite terrace and three feet above it to the high-water mark gives sixty-five million tons of tufa deposited in the basins of the two lakes in question.

[4] Dana, E S., Bull. No. 12, U. S. Geol. Surv., 1884.

Assuming that the calcium has been brought into the Lahontan Basin in the same ratio to the sum of the sodium and potassium as it is being brought in by the present rivers and calculating how much calcium carbonate would have to be deposited to have maintained the same ratio to the sodium and potassium in the present lakes gives in round numbers one hundred million tons. As this figure is approximately the same as the amount of tufa deposited, it indicates that Pyramid Lake is a remnant of Lake Lahontan and that the latter has never been completely desiccated.

If this be true it is possible to approximate the age of Lake Lahontan by computing the number of years necessary for the Truckee River, the only important stream at present flowing into Pyramid and Winnemucca lakes, to carry into the lakes the amount of salt at present in solution. Several independent determinations were made, using the total solids, and such of the individual salts as were likely to have suffered little loss through deposition. Of these the chlorine gave the maximum figure, 4,500 years, while the others ranged from a thousand to 2,500 years. Unfortunately the Truckee flows also into Winnemucca Lake and there is some evidence that the latter may have been desiccated since the beginning of Lake Lahontan. Further, in times of high water Pyramid Lake has discharged into Winnemucca and it is uncertain how much saline material may have been lost by burial in the Winnemucca basin, if any. Judging from the correspondence between the actual amount of tufa deposited and the amount that should have been deposited, as indicated by the amount of salines still present in the lake waters, it is believed that the loss from this source has been slight.

A comparison of the total solids in the lakes to-day with those present at the time of Russell's visit when the lake was practically at the same level gives two thousand years as having elapsed since the basins first began to fill. From these concordant results it is probable that Lahontan first began to form within the last five thousand years.

There is abundant evidence of the comparative recent formation of the terraces, beach lines, and other shore phenomena of the ancient lake in their freshness and absence of erosion. Even where there is a considerable drainage basin behind them the terraces are barely notched by the streams that cross them and any one who is familiar with the erosive power of the not infrequent cloudbursts of Nevada can but wonder that the records of the old lake have stood so long without extensive defacement. Although faulting is still in progress, yet the shore lines and sediments of Lahontan have suffered little displacement. Careful measurements of the elevation of the terraces in different parts of the basin show them to still be horizontal.

Estimates go to show that if the rainfall of the drainage basin increased to somewhat less than double the present rainfall the Lahontan Basin would again fill to its former level. The recent work of Huntington[5] with the big trees of California indicates that there was such an increased rainfall in the immediate vicinity of the Lahontan Basin at the time it is believed the old lake was at its height.

While the work is still in progress yet it is so nearly finished that it is not believed that the above conclusions will be materially modified. The conclusion that Lahontan has never been completely desiccated and that the waters of Pyramid and Winnemucca lakes are residuals makes it possible to forecast the amounts of potassium deposits in the portions of the Basin that are at present desiccated. An estimate made for the Black Rock Desert indicated that if all the potash deposited from Lahontan were segregated in a single square mile it would form a deposit only three inches thick, and if potash beds are found in this desert they must have been formed in the buried sediments of a lake of which we have no knowledge at present.

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[5] Huntington, Ellsworth, Rept. of Smithsonian Inst., for 1912, pp. 383–412, 1913.

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and seventy-second regular meeting of the society was held at Columbia University on Saturday, October 31. The attendance at the morning and afternoon sessions included thirty-eight members. Vice-president L. P. Eisenhart occupied the chair. The Council announced the election of the following persons to membership in the Society: Dr. H. R. Kingston, University of Manitoba; Mr. Colin MacLennan, Havana Electric Railway, Light and Power Company; Mr. E. E. Moots, Walla Walla, Wash.; Mr. C. N. Reynolds, Jr., Harvard University; Dr. Joseph Rosenbaum, New Haven, Conn.; Dr. Joseph Slepian, Cornell University; Dr. Anna H. Tappan, Iowa State College; Dr. Mabel M. Young, Wellesley College. Several applications for membership were lost in the fire in the society's office; the secretary will be glad of any information regarding these. Four new applications were received.

A list of nominations of officers and other members of the council was prepared for the official ballot for the annual election in January. A committee was appointed to audit the treasurer's accounts for the current year. Arrangements were made for adjusting the insurance on the property of the society destroyed by the fire and for refitting the office with the most essential appliances.

The following papers were read at this meeting:

G. M. Green: "On completely integrable systems of homogeneous linear partial differential equations."

G. A. Pfeiffer: "Contributions to the conformal geometry of analytic arcs."

C. A. Fischer: "Conditions for a minimum of an n-fold integral."

Mr. E. C. Kemble: "Note on the definition of work."

H. S. White: "Census of the triad systems on 15 letters."

Edward Kasner: "A law of reciprocity in the calculus of variations."

K. P. Williams: "Concerning a certain totally discontinuous function."

T. H. Gronwall: "Some remarks on conformal representation."

The Southwestern Section of the society will meet at the University of Nebraska on November 28. The Chicago meeting of the society will be held on December 28–29, and the annual meeting in New York on January 1–2. At the annual meeting President E. B. Van Vleck will deliver his presidential address on "The rôle of the point set theory in geometry and dynamics."

F. N. COLE,
Secretary

THE AMERICAN PHILOSOPHICAL SOCIETY

AT a meeting of the American Philosophical Society held on November 6, Professor Eric Doolittle made a communication on "The Determination of the Longitude of the Flower Observatory of the University of Pennsylvania." This determination was effected by an employment of the wireless signals sent out by our government through the department of the Navy in their recent important international longitude campaign.

As is well known to astronomers, a long series of these wireless signals were interchanged on each night, from October, 1913, to March of the present year, between the powerful wireless station at Radio, Virginia, and the station at the Eiffel tower. The result of this work has, of course, not yet been reached definitively, but from the preliminary reductions it seems evident that the difference in longitude between these two widely separated stations will be determined with an accuracy which has never before been approached.

The process of determining the longitude of the Flower Observatory was described in detail by the lecturer, the very full directions sent by the Naval Observatory to the other observatories of our country having been closely followed in the work. The observations were continued from November 17 to December 20; the results of the 55 comparisons were in unexpectedly close agreement. The probable error of the final mean was but 0.015 sec., though it is probable that the effects of the personal equation have not been entirely eliminated from this result. The variation of the individual values was considerably less than that of those obtained three years ago by the ordinary telegraphic method, but the final value, as found, was about 0.1 sec. smaller than that found previously. It is evident, however, that the wireless method is one of extreme accuracy and probably the most accurate of all methods available.

The success of this work is due in no small degree to the continued courtesy and help of the officials of the Naval Observatory. From no account of wireless longitude determination, however brief, should there be omitted a word of appreciation of the work which they have now so nearly completed—a work excellently planned and ably executed, which is a contribution of enduring value to the science of exact astronomy.

THE NEW ORLEANS ACADEMY OF SCIENCES

The regular monthly meeting of the New Orleans Academy of Sciences was held in Stanley Thomas Hall, Tulane University, on Tuesday, October 20. President W. B. Gregory presided, with a large attendance of fellows and members. The president announced that during the summer a room had been furnished and equipped in the Stanley Thomas Hall for the library of the academy. The paper of the evening was read by Dr. C. C. Bass, professor of experimental medicine, on "Pyorrhea Alveolaris." The speaker said in part:

Pyorrhea alveolaris is almost a universal disease. It begins in childhood or early adult life in practically all people. It is usually unrecognized by the patient until one or more teeth get sore and loose in the socket. By a long suppurating process the peridental membrane, which holds the tooth in place, is destroyed, and the tooth is lost. This process goes on from year to year and tooth after tooth is lost, until finally all are removed by the disease or by necessary dental operation.

The cause of the disease has been found to be *ameba buccalis,* which destroys the peridental membrane, separating the tooth first from its gum and later the alveolar process or bony socket.

Emetine hydrochloride injected hypodermatically one half grain daily for three or four days, destroys the demonstrable amebæ in most cases and great improvement and cure of mild or early disease results. The treatment should be repeated one or more times in most cases, however, after an interval of one to four weeks. All patients and perhaps everybody should apply ipecac to their normal or diseased gums by brushing the teeth once a day with a wet brush on which one or two drops of fluid extract of ipecac are placed. The ipecac (from which emetine is made) should prevent the disease and apparently may cure it where not deep seated.

There was considerable discussion of the paper, in which Drs. Belden, Wallace, Wood, Mann and others took part. A unanimous vote of thanks was accorded the speaker at the end of his interesting paper.

R. S. Cocks,
Secretary

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 475th regular meeting of the society, held October 21 in the Public Library, Dr. D. S. Lamb, editor of the *Washington Medical Annals,* delivered an address on "Sanitation in Ancient Civilizations." The need of sanitation was especially shown by the histories of epidemics; for instance, the black death of the fourteenth century destroyed, it is said, about 25,000,000 persons. Pure water was one of the first necessities. Man must have availed himself at first of the use of springs, lakes and streams; later he dug wells and built cisterns, and still later built aqueducts. Old artesian wells are found in Asia Minor, Persia, China, Egypt, Algeria and even the Desert of Sahara. There were ancient aqueducts in Palestine, Greece, Mexico, Guatemala and Peru. Rome at one time had nineteen aqueducts, fourteen of which were large and had a total length of 359 miles. When the king of Persia traveled, he had the water boiled before drinking it. Among the Hebrews waste was buried or burned. The Romans built great sewers or cloacæ, several of which are still in use. At one time the sewers were cleaned out at a cost of a million dollars.

The dead, after battle, were usually buried in large pits or burned. To open such pits or church vaults and old burial grounds sometimes caused sickness and even death. The Egyptians embalmed the dead. Infants were often buried beneath the habitation. The dead were generally cremated in ancient Mexico, and in Rome from 450 B.C. until the spread of Christianity. In Greece the dead were buried near the houses of the living. Indian mounds in the United States contain the bodies of the dead. Hot-air baths and sweat baths were found among the ancients. Soap was mentioned by Pliny about A.D. 25 and was said to have been brought from Germany. The Hebrews were required by religious regulations to be clean in person, clothing and houses. The Romans had many public baths free to all. The Greeks bathed daily. The Hebrews attempted to segregate the lepers. Circumcision was common among the Egyptians and in many other parts of the world. Among the Hebrews it was a religious ceremonial. The Egyptians tabooed some articles of food, believing that diseases were contracted through them. The Hebrews had many rules of diet with the force of religious injunctions; especially as to meat, the animal was to be slaughtered in a certain way, with much attention to detail.

Daniel Folkmar,
Secretary